Fecal Coliform and *Escherichia coli* Bacteria Total Maximum Daily Load Evaluations for the West Fork of the Vermillion River South Dakota

South Dakota Department of Environment and Natural Resources

Protecting South Dakota's Tomorrow ... Today

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Total Maximum Daily Load Summary

West Fork of the Vermillion River - Segment R9 (South Dakota)

Waterbody Type:	River/Stream
303(d) Listing Parameter:	Pathogens (*Escherichia coli* and fecal coliform)
Initial Listing Date:	2010 IR
Designated Uses of Concern:	Limited Contact Recreation Waters
Size of Impaired Waterbody:	Segment R9 - Approximately 103.97 km in length Entire length – Approximately 165.42 km in length
Size of Watershed:	Segment R9 - 71,799.2 hectares (ha) Entire Subwatershed Size - 101,583.6 hectares (ha)
Indicator(s):	Concentration of *Escherichia coli* and fecal coliform (colony forming units per 100ml)
Analytical Approach:	Bacteria Source Load Calculator (Ver 3.0) with Load Duration Curve Framework
Location:	Hydrologic Unit Codes (8-digit HUC): 10170102
Goal:	Meet applicable water quality standards for *Escherichia coli* and fecal coliform
TMDL Priority Ranking:	Priority 1 (2010 IR)
Target (Water Quality Standards):	*Escherichia coli* - Maximum daily concentration of ≤ 1,178 CFUs/100mL and a geometric mean of ≤ 630 based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period. . Fecal coliform - Maximum daily concentration of ≤ 2,000 CFU/100mL and a geometric mean of ≤ 1,000 based on a minimum of five (5) samples obtained during separate 24-hour periods for any 30-day period and they may not exceed this value in more than 20 percent of the samples examined in this same 30-day period. Both of these criteria apply from May through September.
Reach Number:	Segment R9: SD-VM-R-VERMILLION_WEST_FORK_01_USGS

1.0 Objective

The intent of this document is to clearly identify the components of the TMDL, support adequate public participation, and facilitate the US Environmental Protection Agency (US EPA) review. The TMDL was developed in accordance with Section 303(d) of the federal Clean Water Act and guidance developed by US EPA. This TMDL document addresses the pathogen impairment of Segment R9 of the West Fork of the Vermillion River (McCook-Miner County Line to the Vermillion River), which has been assigned to a priority category 1 (high-priority) in the 2010 and 2012 impaired waterbodies list.

2.0 Watershed Characteristics

2.1 General

The project area for Segment R9 is shown in Figure 1. The West Fork of the Vermillion River drains approximately 251,010 total acres (392 miles^2) in southeastern South Dakota (SD). But only 177,413.4 acres will be covered via this TMDL based on the listing within the SD administrative rules (ARSD) (Table 1). Only 64.6 miles of the entire 102.7 miles length is classified with the limited contact recreation beneficial use draining the 177,413.4 acres. Minor intermittent tributaries merge with the West Fork prior to its confluence with the East Fork where together they form the mainstem of the Vermillion River near Parker, SD (Figure 1).

Segment R9 of the West Fork of the Vermillion River is currently classified with the following beneficial uses:

Chapter 74:51:03:01 of the South Dakota Administrative Rules assigns all streams in South Dakota the beneficial uses of:

> *Beneficial Use Classification 9: Fish and wildlife propagation, recreation, and stock watering waters*
> *Beneficial Use Classification 10: Irrigation waters*

Chapter 74:51:03:25 of the South Dakota Administrative Rules assigns the following additional beneficial use classifications to the East Fork of the Vermillion River from the Vermillion River to the McCook-Miner County Line:

> *Beneficial Use Classification 6: Warmwater marginal fish life propagation waters*
> *Beneficial Use Classification 8: Limited contact recreation waters*

The West Fork of the Vermillion River watershed is located in the James River Lowland Level IV ecoregion which is part of the greater Northern Glaciated Plains. A flat to gently rolling landscape composed of glacial drift characterizes the Northern Glaciated Plains ecoregion. This ecoregion is also characterized by dense concentrations of temporary and seasonal wetlands. Native grasses include western wheatgrass, green needlegrass, big bluestem, and blue grama but most areas are extensively tilled to corn and soybeans interspersed with pastureland (Bryce et al., 1996 and Chapman et al., 2001). Wildlife species present in the area include whitetail deer, red fox, beavers, raccoons, ring-necked pheasants, mourning doves, and numerous other species of songbirds, waterfowl, reptiles, and amphibians (SD Game, Fish, and Parks, 2002).

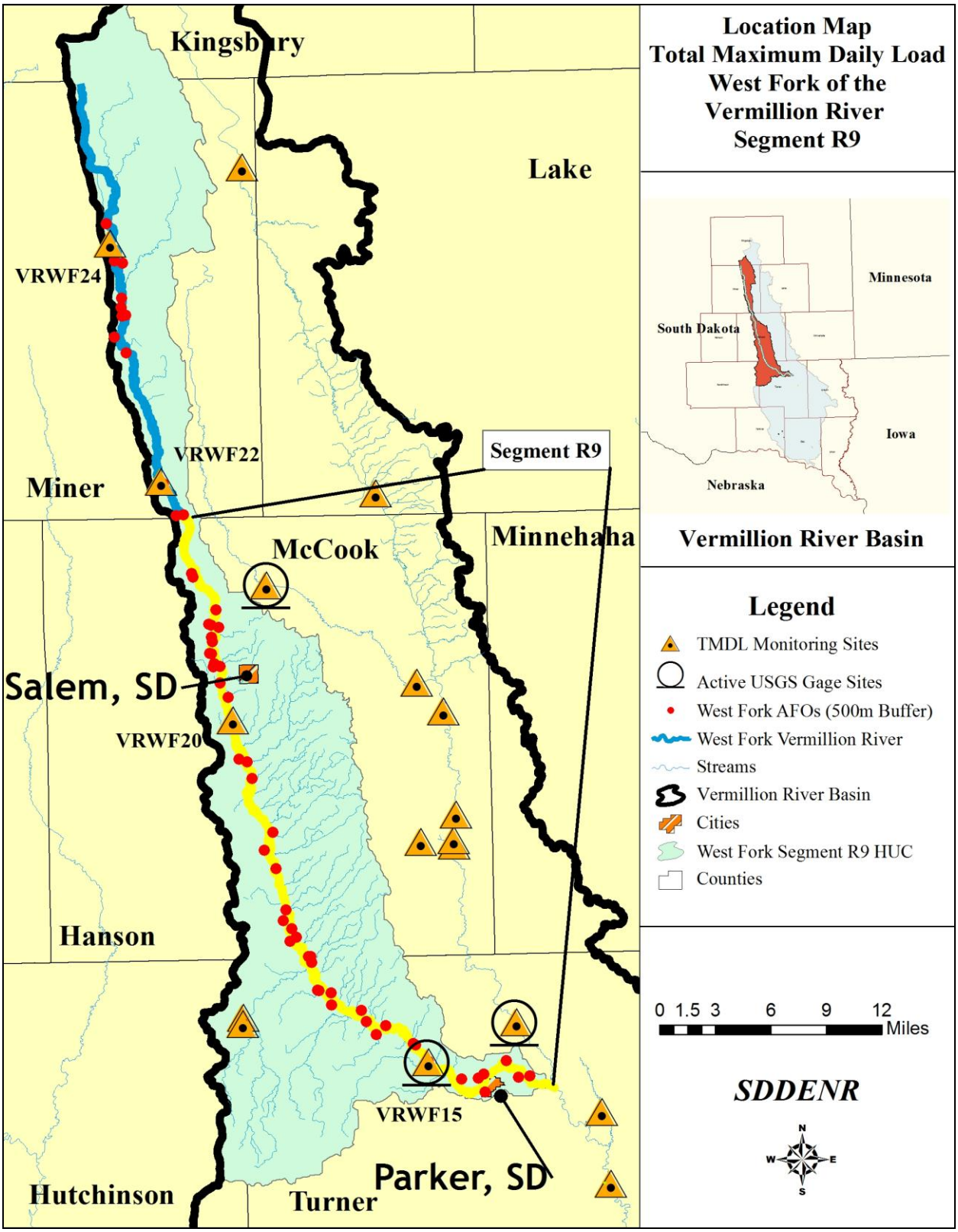

Figure 1. Location of Segment R9, West Fork Vermillion River (South Dakota).

Table 1. West Fork of the Vermillion River Assessment Reach and Segment Designations.

Segment	Length miles	Description	South Dakota Monitoring Stations for Mainstem River	
			Mainstem Sites	Tributary Sites
SD-VM-R-VERMILLION_WEST_FORK_01_USGS	64.6	Vermillion River to McCook-Miner County Line	VRWF15 VRWF20	VRWFT16 VRWF22 VRWF24

The West Fork of the Vermillion River is divided into 10 individual HUC12s ranging in size from 14,196 to 33,885 acres. Land uses within these HUCs are generally similar (Table 2). The majority of these areas are dominated by a combination of grassland, hay, pasture, corn, and soybeans land uses. There are insignificant amounts of residential and commercial areas within this rural watershed. The impacts from these two land uses are expected to be minimal (Figure 2). In each of the 10 HUCs approximately 56% or greater of the watershed is dominated by cultivated crops.

Livestock uses are also a significant landuse type within this watershed. During the animal feeding operation (AFO) inventory 60 were found within 500 meters of the mainstem of the West Fork Vermillion River (Figure 1). Each one of the operations was ranked by the Agricultural Nonpoint Source Computer Model (AGNPS). Twenty-six of the AFOs exhibited an AGNPS rating of 50 or greater.

The impaired reach of the West Fork of the Vermillion River lies within central McCook County and northwestern Turner County (Figure 1). Common soil associations on the uplands include Clarno-Bonilla-Tetonka, Crossplain-Clarno-Tetonka, Clarno-Ethan, Crossplain-Dudley, Hand-Ethan-Clarno, and Wentworth-Egan associations. Associations found within steep areas are limited to Ethan-Betts. Along the terraces, floodplains, and foot slopes Davis-Bon-Lamo and Delmont-Hand-Chaska associations can be found. Soils range from well drained to poorly drained, and level to steep (NRCS, 1980). There is a large mix of uplands, swales, and wetland depressions. Erosion rates were determined by through the ANN-AGNPS modeling program.

There are seven communities within the West Fork Watershed. The 2008 populations range from 38 for the city of Dolton, SD to 1,321 for the city of Salem,SD. Many of these municipalities have discharge permits. The information from these municipal WWTF was included in the TMDL. Although the city of Freeman, SD is within the watershed boundary the WWTF is located west of the city and falls within the James River Watershed which is why it is not included as part of the WLA.

City	Canistota	Dolton	Freeman	Howard	Marion	Parker	Salem
2008 Pop.	656	38	1,194	891	825	983	1,321

The Vermillion River basin has a subhumid, continental climate characterized by pronounced seasonal differences in temperature, precipitation, and other climatic variables. Temperature varies slightly from the northern to the southern end of the basin. Annual temperatures are slightly cooler at the northern parts of the basin. January is typically the coldest month (13°F in

the north and 19°F in the south). July is typically the warmest month (73°F in the north and 75°F in the south). Figure 1 shows that the West Fork of the Vermillion River is located in the northern part of the basin.

The frost free days at the northern end of the basin are typically from May 17th to September 21st, while the southern frost free days are from May 4th to October 5th. The average annual precipitation in the watershed is somewhat variable, both spatially and temporally, ranging from 22 to 26 inches Generally, average annual precipitation decreases as you move north within the study watershed. Average seasonal snowfall for this region is approximately 30 inches.

The average rainfall in the West Fork watershed is approximately 22 inches per year with 64% falling during the May through September (1949-2006). The average annual snowfall is approximately 34 inches but varies widely from year to year. As shown on Figure 1 and Table 1, there were five monitoring stations located within West Fork watershed.

Although the West Fork of the Vermillion River is approximately 102.8 miles in length, the water quality standards only apply from the McCook/Miner County Line to the Vermillion River just southeast of Parker, SD (Figure 1, Table 1). There are no long-term ambient WQM stations on this segment. The data used to determine impairment were temporary stations installed as part of the overall Vermillion River Basin Watershed Assessment (Appendix A). The data collected from these stations during the period 2004-2006 indicated an impairment of the limited contact recreational use caused by bacteria on this segment

The West fork of the Vermillion River was assessed as an individual portion of the larger Vermillion River Basin Watershed Assessment, which looked at individual streams such as West Fork as well as the entire drainage basin and the cumulative effects of the individual waterbodies.

South Dakota has recently adopted *Escherichia coli* criteria for the protection of the limited contact and immersion recreation uses. The data from the West Fork of the Vermillion River indicated that both pathogen indicators were causing the limited contact recreational impairment requiring an *E. coli* and fecal coliform TMDL.

Segment SD-VM-R-VERMILLION_WEST_FORK_01_USGS (MAPID: Segment R9) was listed for both pathogen indicators in the 2010 and the 2012 Integrated Report (SDDENR, 2010 2012). Previous listings for this segment indicated insufficient data or nonassessed for support of the limited contact beneficial use. This TMDL document addresses both the *E. coli* and fecal coliform bacteria impairments.

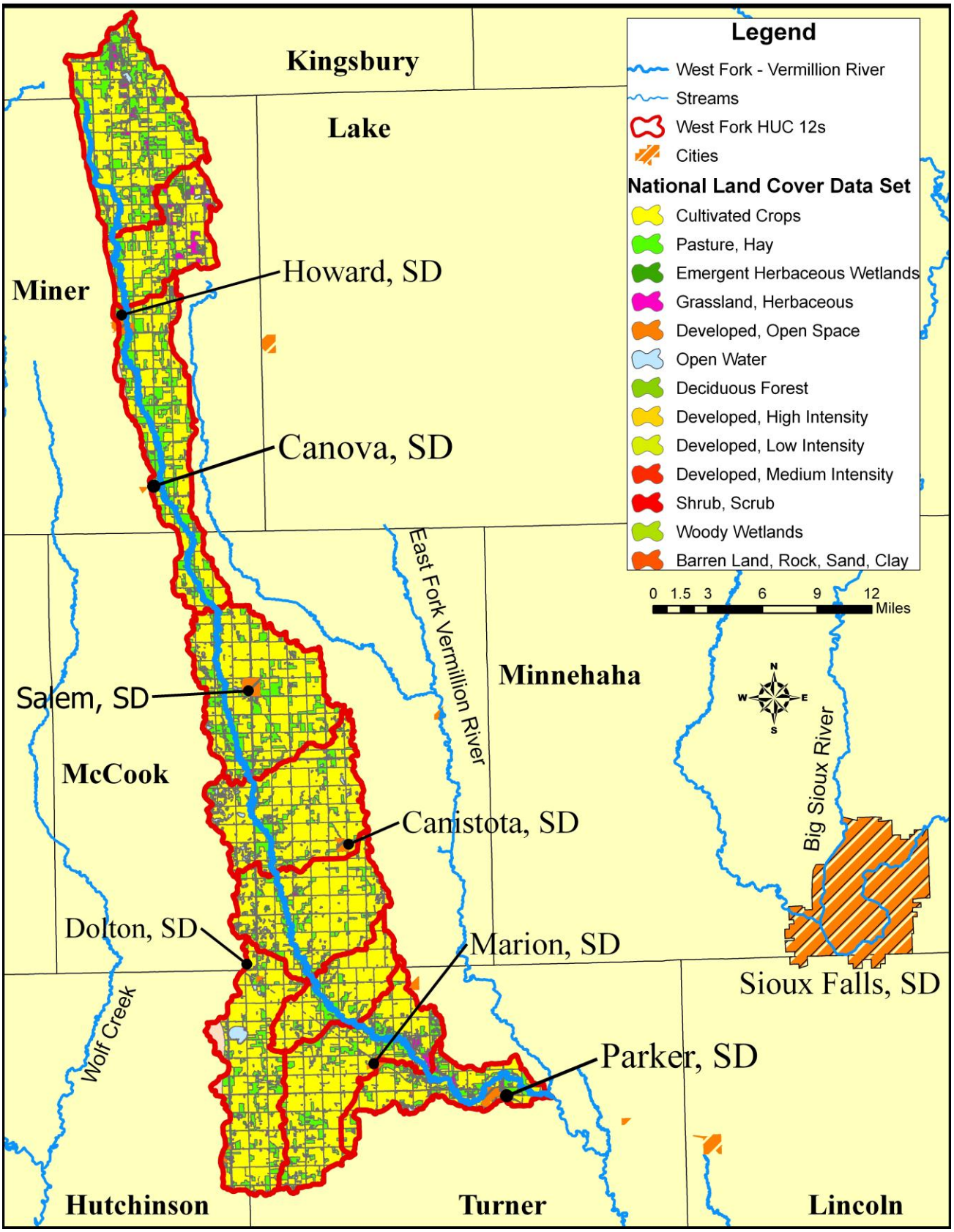

Figure 2. Landuse for the West Fork of the Vermillion River (2001 NLCD).

Table 2. Landuse for the West Fork of the Vermillion River using the 2001 National Land Cover Data Set.

12-digit Hydrologic Units for the West Fork of the Vermillion River

	101701020501	101701020502	101701020503	101701020504	101701020601	101701020602	101701020604	101701020603	101701020605	101701020606
2001 National Land Cover Data Set Landuse Category	**Headwaters of West Fork Vermillion River**	**West Fork Vermillion River- Howard Creek**	**West Fork Vermillion River- Unityville Slough**	**West Fork Vermillion River- Salem Creek**	**West Fork Vermillion River- Canistota Creek**	**West Fork Vermillion River- Stanley Corner Creek**	**West Fork Vermillion River- Langrock Creek**	**Dolton Township Tributary**	**West Fork Vermillion River- Bethesda Church Creek**	**Mouth of West Fork Vermillion River**
11-Open Water	0.6%	0.5%	0.1%	0.5%	2.2%	0.6%	0.1%	2.1%	0.2%	0.5%
21-Developed, Open Space	3.7%	3.9%	4.2%	5.3%	4.8%	4.7%	4.4%	5.9%	4.8%	5.9%
22-Developed, Low Intensity	0.1%	0.1%	0.5%	1.2%	0.6%	0.4%	0.2%	1.0%	0.4%	2.0%
23-Developed, Medimum Intensity	0.0%	0.0%	0.1%	0.4%	0.1%	0.1%	0.0%	0.2%	0.1%	0.6%
24-Developed High Intensity	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
31-Barren Land, Rock, Sand, Clay	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
41-Deciduous Forest	0.5%	0.4%	0.2%	0.2%	0.1%	0.3%	0.2%	0.2%	0.5%	0.6%
52-Shrub, Scrub	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
71-Grassland, Herbaceous	4.9%	9.3%	1.8%	1.3%	1.2%	1.4%	1.2%	1.0%	3.5%	6.0%
81-Pasture, Hay	**31.7%**	**21.8%**	**36.5%**	**23.0%**	**13.5%**	**13.6%**	**13.2%**	**16.3%**	**18.3%**	**22.9%**
82-Cultivated Crops	**56.8%**	**62.7%**	**55.8%**	**66.3%**	**75.2%**	**76.5%**	**80.1%**	**72.2%**	**71.4%**	**60.6%**
90-Woody Wetlands	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
95-Emergent Herbaceous Wetlands	1.6%	1.4%	0.8%	1.5%	2.3%	2.3%	0.6%	1.0%	0.8%	0.7%
Total Acres (251,010)	**32,927**	**16,709**	**28,583**	**33,885**	**29,079**	**25,831**	**14,196**	**25,401**	**29,141**	**15,259**
Total Hectares (101,584)	**13,325**	**6,762**	**11,568**	**13,713**	**11,768**	**10,454**	**5,745**	**10,280**	**11,794**	**6,175**

Land use/land cover, livestock, wildlife, septic tanks and sewerage systems are a determinant in identifying and quantifying sources of pathogens within a watershed. Table 2 shows the significant percentages of the 15-land use categories taken from the 2001 National Land Cover Data set (NLCD, 2001) for the West Fork of the Vermillion River in southeastern SD. This table lists both the total acreage and the percent land uses.

3.0 Problem Identification

Pathogen sources are overland runoff from nearby croplands and feedlots, inflow from tributaries, and septic tanks.

As part of the Vermillion River Basin Watershed Assessment Project, the West Fork of the Vermillion River was first listed as impaired due to exceedence of fecal coliform and *E. coli* criteria in the 2010 Integrated Report. Without an established WQM station, support status of the beneficial uses was unknown until a final review of the watershed assessment data was completed. This project collected data at more than thirty sites for approximately two years ending in 2006. Data from the watershed assessment were used to determine support status of the beneficial uses. Methodology used to determine support status is described in South Dakota's Integrated Report, which is submitted to EPA biennially (SDDENR 2012). In brief:

"For Streams: >10% violation rate (3 or more exceedances between 10 and 19 samples) for daily maximum criteria. >10% violation rate (2 or more exceedances between 2 and 19 samples) for 30-day average criteria."

"To ensure a sufficient number of samples were available for each stream segment (usually a minimum of 20) the period of record considered for this report was from October 1, 2006, to September 30, 2011, (5 years) for streams."

Since 1961, the USGS has operated a gaging station on the West Fork of the Vermillion (USGS Gage# 06478690). Water Quality data was collected at VRWF15 beginning in 2005 and was collected through 2006 (Table 6). Water quality monitoring over this period showed that approximately 18% of *E. coli* samples and 14% of the fecal coliform samples exceeded the daily maximum standard for Segment R9. Across all sites, maximum concentrations ranged from 2,000 colony-forming units per 100 mL (CFU/100mL) up to >20,000 CFU/100mL (too numerous to count). Most of the samples that exceeded criteria were collected across all flow conditions (Figure 3 and 4). Table 3 summarizes the sampling results for Segment R9. All samples and their corresponding flows can be found in Appendix A.

Figures 3 and 4 show the *E. coli* and fecal coliform concentrations categorized by flow. Four flowzones are shown: High, Moist, Mid-Range, and Dry. Violations of the both pathogen criterion occurred across all flow conditions are clearly driven by flow. In fact, the most significant violations were sampled during storm events (>50% stormflow) (Figure 4). Higher flowzone violations are indicative of streambank erosion in both the mainstem and tributaries along with sheet and rill erosion from farm field runoff during moist conditions (Cleland, 2003). Lower flow violations can be attributed to sediment delivered from tributaries from smaller storm events, continued bank erosion, and the existing sediment load contained within the river.

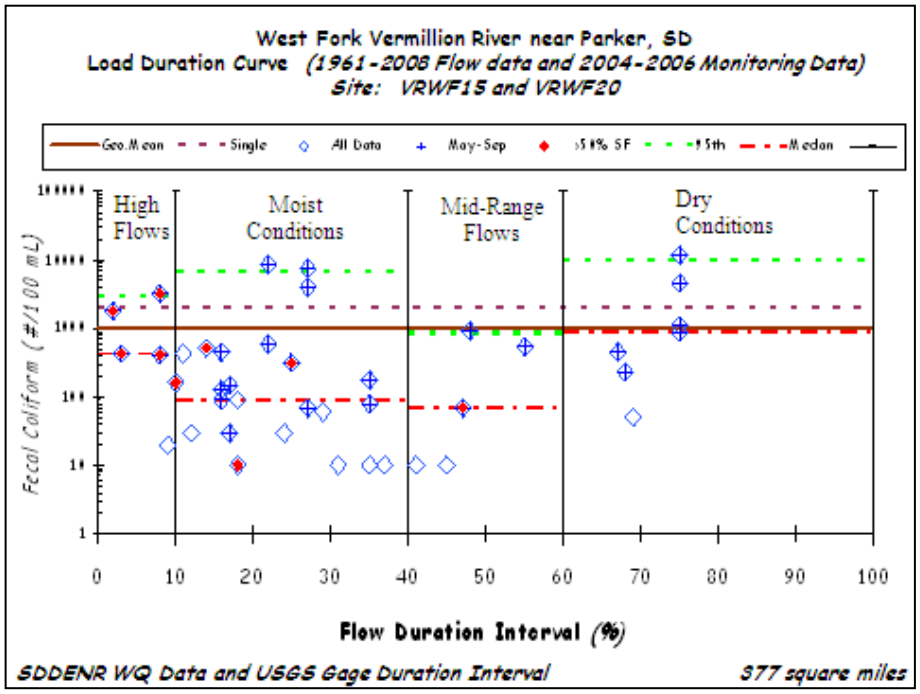

Figure 3. Site VRWF15 and VRWF20 fecal coliform concentrations for each of the four flowzones.

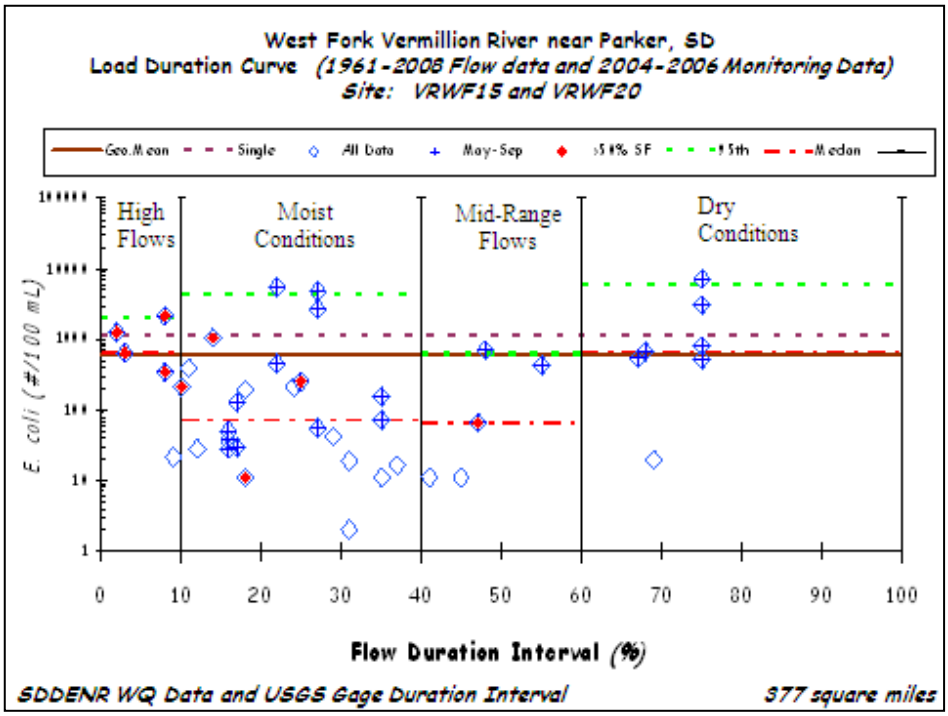

Figure 4. Site VRWF15 and VRWF20 *E. coli* concentrations for each of the four flowzones.

Four flowzones were used for the West Fork of the Vermillion River because of the natural breaks with the flow distribution and the limited number of samples collected in the lowest zone (90-100%). The median flow for the 60-90% zone compared to 60-100% zone was 0.14 cfs vs. 0.001 cfs, respectively. For the lowest flow zones a 52% reduction for fecal coliform and a 51% reduction for *E. coli* are needed. Creating an additional lower zone will not change the source allocation nor will it change the remediation efforts, i.e. they would remain the same.

Table 3. Summary Table of Sampling Results for Segment R9.

Data	StationID		All Data
	VRWF15	VRWF20	
Count of Fecal Coliform (cfu/100mL)	22	21	43
Average of Fecal Coliform (cfu/100mL)2	300	2,099	1,179
Max of Fecal Coliform (cfu/100mL)	1,800	12,000	12,000
Min of Fecal Coliform (cfu/100mL)2	10	10	10
# of Samples > 1,000 CFU/100mL (Chronic)	2	6	8
# of Samples > 2,000 CFU/100mL (Daily Max)	0	6	6
Date of First Sample	4/19/2005	3/31/2005	
Date of Last Sample	11/20/2006	11/29/2006	
Count of E.coli (cfu/100mL)	22	21	43
Average of E.coli (cfu/100mL)2	242	1,422	818
Max of E.coli (cfu/100mL)	1,285	7,320	7,320
Min of E.coli (cfu/100mL)2	2	11	2
# of Samples > 630 CFU/100mL (Chronic)	3	9	12
# of Samples > 1,178 CFU/100mL (Daily Max)	1	6	7
Max of Flow Rank*(Higher Flows)	76.6%	76.6%	76.6%
Min of Flow Rank* (Lower Flows)	2.3%	3.5%	2.3%
Date of First Sample	4/19/2005	3/31/2005	
Date of Last Sample	11/20/2006	11/29/2006	
Baseflow Sampling	Yes	Yes	
Event Sampling	Yes	Yes	
Monthly Sampling	Yes	Yes	
*Percent flow rank indicates what percent of the time the flow meets or exceeds shown percentage.			

4.0 Description of Applicable Water Quality Standards & Numeric Water Quality Targets

4.1 South Dakota Water Quality Standards

Each waterbody within SD are assigned designated or beneficial uses. All waters (both lakes and streams) within SD are designated with the use of fish and wildlife propagation, recreation, and stock watering. All streams are assigned the use of irrigation. Additional uses are assigned by the state based on a beneficial use analysis of each waterbody. Water quality standards have been defined in SD state statutes in support of these uses. These standards consist of suites of criteria that provide physical and chemical benchmarks from which management decisions can be developed.

Chronic standards, including geometric means and 30-day averages, are applied to a calendar month. While not explicitly described within the water quality standards, this is the method used in the South Dakota Integrated Water Quality Report (IR) as well as in permit development.

Additional "narrative" standards that may apply can be found in the "Administrative rules of South Dakota: Articles 74:51:01:05; 06; 08; 09; and 12". These contain language that generally prohibits the presence of materials causing pollutants to form, visible pollutants, and nuisance aquatic life.

The West Fork of the Vermillion River from the confluence of the East and West Fork to the McCook/Miner County line has been assigned the beneficial uses of: warm water marginal fish life propagation, irrigation waters, limited contact recreation, and fish and wildlife propagation, recreation, and stock watering. Table 4 lists the criteria that must be met to support the specified beneficial uses. When multiple criteria exist for a particular parameter, the most stringent criterion is used.

4.2 Water Quality Targets

Of all the assessed parameters for which surface water quality criteria are established (Table 4), *E. coli* and fecal coliform exceeded criteria for the limited contact recreation beneficial use. These two TMDLs will address the limited contact recreation pathogen impairments.

The numeric TMDL targets established for the West Fork are 630 cfu/100 ml and 1,000 cfu/100 ml for *E. coli* and fecal coliform, respectively. Both of these targets are based on the threshold of the chronic standard. The *E. coli* criteria for the limited contact recreation beneficial use requires that 1) no sample exceeds 1,178 cfu/100 ml and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 630 cfu/100 ml. These criteria are applicable from May 1 through September 30.

The fecal coliform criteria for the limited contact recreation beneficial use requires that 1) no sample exceeds 2,000 cfu/100 ml and 2) during a 30-day period, the geometric mean of a minimum of 5 samples collected during separate 24-hour periods must not exceed 1000 cfu/100 ml. These criteria are applicable from May 1 through September 30.

Table 4. South Dakota surface water quality standards for the West Fork of the Vermillion River, McCook, Miner, and Turner Counties, South Dakota.

Parameter	Criteria	Unit of Measure	Special Conditions
Total alkalinity as calcium carbonate	≤ 750	mg/L	30-day average
	≤ 1313	mg/L	daily maximum
Chlorides (warmwater marginal)	≤ 100	mg/L	30-day average
	≤ 175	mg/L	daily maximum
Dissolved oxygen (warmwater marginal)	≥ 5.0	mg/L	Daily minimum May 1-Sept. 30
	≥ 4.0	mg/L	Daily minimum Oct 1-April 30
Total ammonia nitrogen as N (warmwater marginal)	Equal to or less than the result from Equation 3 in Appendix A	mg/L	30-day average May 1 - October 31
	Equal to or less than the result from Equation 4 in Appendix A	mg/L	30-day average November 1 – April 30
	Equal to or less than the result from Equation 2 in Appendix A	mg/L	daily maximum
Fecal coliform and *E. coli* (May 1 – September 30) (limited contact recreation)	≤ 1,000 (*E. coli* ≤ 630)	cfu/100 mL	geometric mean based on a minimum of 5 samples obtained during separate 24-hour periods for any 30-day period
	≤ 2,000 (*E. coli* ≤ 1,178)	cfu/100 mL	in any one sample
Conductivity at 25°C	≤ 2,500	micromhos/cm	30-day average
	≤ 4,375	micromhos/cm	daily maximum
pH (warmwater marginal)	≥ 6.0 and ≤ 9.0	standard units	see § 74:51:01:07
Nitrates as N	≤ 88	mg/L	daily maximum
	≤ 50	mg/L	30-day average
Total dissolved solids	≤ 2,500	mg/L	30-day average
	≤ 4,375	mg/L	daily maximum
Total Suspended Solids (warmwater marginal)	≤ 150	mg/L	30-day average
	≤ 263	mg/L	daily maximum
Temperature (warmwater marginal)	≤ 90	°F	see § 74:51:01:31
Undisassociated hydrogen sulfide	≤ 0.002	mg/L	
Total petroleum hydrocarbon	≤ 10	mg/L	see § 74:51:01:10
Oil and grease	≤ 10	mg/L	see § 74:51:01:10
Sodium adsorption ratio	≤ 10		see definition

During this study, each of the West Fork monitoring sites shown in Tables 3 and 5 exhibited several samples that exceeded the daily maximum criterion of 2,000 cfus/100ml and 1,178 cfus/100ml for fecal coliform and *E. coli*, respectively. Bacteria was listed as the cause of impairment for Segment R9 listed in the SD 2010 Impaired Waterbodies List. Table 5 shows significant differences in violations rates between flowzones.

The numeric TMDL targets established herein for Segment R9 limited contact recreation use is based on the chronic threshold taken from South Dakota's 30-day geometric mean for fecal coliform and *E. coli* criterion. The chronic threshold represents the numeric target of the chronic standard whereas the chronic standard represents the geometric mean of a minimum of five samples collected within a 30-day period. The numeric targets of 1,000 cfu/100mL for fecal coliform and 630 cfu/100mL for *E. coli* established for Segment R9 took into consideration all current water quality standards and will ensure that both the chronic and acute standards are met.

Table 5. Exceedance Rate of the fecal coliform Daily Maximum Criterion for two sites on the West Fork of the Vermillion River (2,000 cfu/100ml).

			High	Moist	Mid	Dry
Segment R9	VRWF15+VRWF20	Samples per Zone	5	25	6	7
		Exceedances per Zone	1	3	0	2
		%Violation	20%	12%	0%	29%

5.0 Data Collection Method

5.1 Water Quality Data and Discharge Information

Stream discharge information collected from 34 sites was used to develop stage/discharge curves for each monitoring site. Both targeted TMDL sites and ambient (monthly) monitoring data were used to assess impairments and develop trend information. Table 6 shows sites used and numbers of samples collected during the project period. Those sites used for the West Fork of the Vermillion River are in bold (Sites VRWF15, VRWF20, and VRWF22).

The design of the assessment project was used to identify beneficial use impairments and estimate the sediment and nutrient loadings within the Vermillion River and major individual tributaries in the watershed through hydrologic, chemical and biological monitoring. The information was not only used to develop a TMDL for the Vermillion River but also locate critical areas in the watershed to be targeted for implementation.

A continuous stage record for the project period, with the exception of winter months after freeze up was maintained for each site. Discrete discharge measurements were taken on a regular schedule and during storm surges. Discharge measurements were taken with a hand-held current velocity meter under wadeable conditions or from a bridge crane during high flows using methods outlined by the U.S. Geological Survey (USGS). Discharge measurements and water level data were used to calculate a stage/discharge table for all stream systems. USGS Gage No.

06478690 has been recording daily discharge information on the West Fork the Vermillion River since 1961.

Samples were collected during spring runoff, storm events, and monthly base flows. Locations of sites monitoring tributaries and the Vermillion River mainstem can be found in Figure 1 and Table 6. Sampling was conducted on a temporal basis over the course of two years (Jan'05 – Dec'06). Five ambient stations were also used to conduct long-term (1968 to Present) trend analysis (TSS or fecal coliform vs. time). The West Fork of the Vermillion River does not have a long-term WQM station. Samples were collected during the spring snowmelt runoff, and baseflow conditions for spring (March 1 to May 31), summer (June 1 to September 15), and fall (September 16 to November 15). Baseflow was defined as no significant increase in flow.

Storm event samples for each season were collected at or as near as possible to the peak discharge. During the project personnel from the Vermillion Basin Water Development collected all samples periodically aided by SDDENR. Autosamplers were used to collect at some of the more remote locations. The autosamplers were programmed to collect composite samples over the course of a storm event.

All sampling and discharge data collection conducted during this project were done with methods in accordance with the South Dakota *Standard Operating Procedures for Field Samplers* developed by the Water Resource Assistance Program and approved by USEPA Region VIII. All samples collected in SD, including the mainstem, were sent to the State Health Laboratory in Pierre, SD for analysis.

Table 6. Site and sample description, and sample numbers collected as part of the West Fork Vermillion River Pathogen TMDL (2004-2006).

Site ID	Description	USGS Gage	Year	Samples	Blanks	Dups	Storm
Blank			2005-06		56		
VR01	Vermillion River at Vermillion, SD		2005-06	5		3	16
VR03	Vermillion River North of Vermillion, SD	6479010	2005-06	7		1	15
VR05	Vermillion River near Hub City, SD		2005-06	10			13
VR06	Vermillion River (Colfax Corner)		2005-06	9		1	14
VR08	Vermillion River at Centerville, SD		2005-06	9		1	13
VR13	Vermillion River near Hurley, SD		2005-06	9		2	16
VREF14	East Fork Vermillion River East of Parker, SD	6478600	2005-06	7		3	18
VREF17	East Lake Vermillion Outlet		2005-06	9			11
VREF19	East Fork Vermillion River near Montrose, SD		2005-06	8		3	17
VREF23	East Fork Vermillion River South of Winfred, SD		2005-06	7		1	12
VREF25	East Fork Vermillion River Outlet from Lake Thompson		2005-06	7		1	10
VREFT18	East Fork Vermillion River Unnamed Tributary		2005-06	3		3	15
VREFT21	Little Vermillion River Outlet near Montrose, SD		2005-06	9		3	16
VREFT29	Little Vermillion River near Salem, SD	6478540	2005-06	1			2
VRELV27	East Lake Vermillion South End		2005-06	43			
VRELV28	East Lake Vermillion North End		2005-06	27		5	
VRSL26	Silver Lake		2005-06	27		4	
VRT02	Yankton Clay Ditch		2005-06	2		1	7
VRT04	Clay Creek Ditch		2005-06	6		3	16
VRT07	Frog Creek		2005-06	9		1	11
VRT09	Turkey Ridge Creek		2005-06	9		2	14
VRT10	Long Creek		2005-06	8		4	13
VRT11	Hurley Creek		2005-06	4		1	12
VRT12	Camp Creek		2005-06	7			10
VRWF15	**WestFork Vermillion River near Marion, SD**	**6478690**	**2005-06**	**9**		**1**	**14**
VRWF20	**West Fork Vermillion River near Salem, SD**		**2005-06**	**8**		**2**	**13**
VRWF22	**West Fork Vermillion River near Canova, SD**		**2005-06**	**8**			**10**
VRWF24	**West Fork Vermillion River near Howard, SD**		**2005-06**	**6**		**2**	**11**
WQM150	East Fork Vermillion River North of Montrose, SD		2005-06	43			
WQM154	East Fork Vermillion River South of Montrose, SD		2005-06	43			
WQM4	Vermillion River near Wakonda, SD		2005-06	53			
WQM5	Vermillion River near Vermillion, SD		2005-06	54			
WQM61	Vermillion River near Parker, SD		2005-06	53			
VRT30	Spirit Mound Creek		2006			3	7
VRT31	Baptist Creek		2006	4		2	5
VRT32	Ash Creek		2006	6		1	5
VRT33	Clay Creek		2006	6		2	5
VRT34	Turkey Creek		2006	8			3
VSS-1	City of Vermillion, 48" Storm Sewer		2006				6
VSS-2	City of Vermillion, 36" Storm Sewer East		2006			1	6
VSS-3	City of Vermillion, 36" Storm Sewer West		2006				5
VSS-4	City of Vermillion, 60" Concrete Storm Sewer East		2006				1

5.2 *Escherichia coli* Translation and Conversion

During the TMDL monitoring project for the Vermillion Basin 43 fecal coliform samples were collected from Segment R9 (Sites VRWF15 and VRWF20) but only 20 *E. coli* samples were collected. Because the two bacterial indicators are closely related (*RESPEC*, 2010) an attempt was made to develop a regression equation to estimate *E. coli* based on the available fecal coliform data. This would increase the number of data points used to develop the LDC and TMDL for *E. coli* for Segment R9 (Figure 5). A regression analysis was performed between the two data pools after a log transformation. The fecal coliform data effectively explains over 70% of the *E. coli* variability and was used to increase the number of *E. coli* observations to 43 (Figure 5). All fecal coliform and E. coli data, including estimated *E. coli* concentrations, can be found in Appendix A.

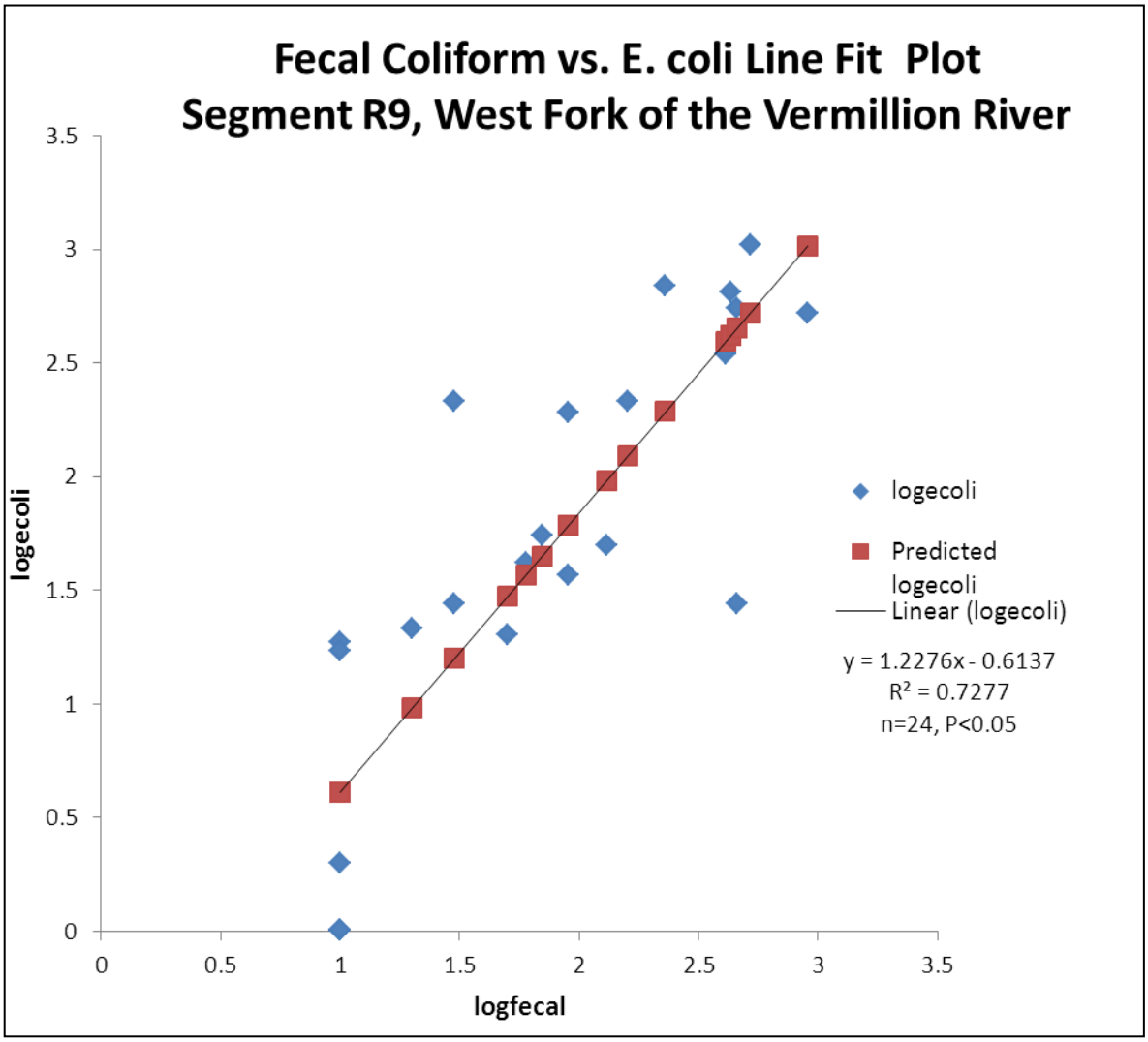

Figure 5. Fecal Coliform - *E. coli* Relationship for the West Fork of the Vermillion River.

6.0 Source Assessment and Allocation

6.1 Point Sources

There are six point sources or NPDES permitted facilities located in the watershed of the West Fork of the Vermillion River (Table 7).

The City of Canistota, SD (NPDES Permit# SD0022497) is located approximately in the southern part of Segment R9. It is a small two-pond system that is authorized to discharge one or two times per year to an unnamed tributary of the West Fork of the Vermillion.

The city of Howard, SD (NPDES Permit# SD0020613) is a small two-pond system in the northern part of the watershed. It is authorized to discharge to an intermittent portion of the West Fork of the Vermillion River that is subject to only beneficial uses 9) fish and wildlife propagation; and 10) irrigation waters. There are no fecal coliform limits established for this permit or receiving waterbody.

The city of Marion, SD (NPDES Permit# SD0020311) is a three-cell waste stabilization lagoon system that requires permission to discharge to the West Fork of the Vermillion River. Stipulations as part of the permit include discharging in the spring and fall when the flow is not at its minimum. Effluent limitations are also outlined in the permit.

The city of Monroe, SD (NPDES Permit# SD0023752) is a small no discharge facility located in north central Turner County (Figure 1). It is a small three-pond system and is permitted for no discharge.

The city of Salem, SD (NPDES Permit#SD0020966) is located in the central part of the of the West Fork watershed. This WWTF consists of three-ponds and requires permission to discharge to the West Fork of the Vermillion River.

These five (Monroe, SD excluded) facilities have been allotted a WLA for both fecal coliform bacteria and *E. coli.*

Table 7. Permitted Facilities within the West Fork Drainage.

Permit Number	Facility Name	System Description	Flow used for WLA (cfs)
SD0022497	CANISTOTA - CITY OF	pond/wetland	0.65
SD0020613	HOWARD - CITY OF*	Pond system	5.62*
SD0020311	MARION - CITY OF	Pond system	3.00
SD0023752	MONROE - TOWN OF	Pond system	0.00
SD0020940	PARKER - CITY OF	Pond system	1.78
SD0020966	SALEM - CITY OF	Pond system	2.85
*Flow not included in WLA for reasons outlined above.			

Table 8 includes the information used by SDDENR to calculate a maximum allowable discharge for each facility. The WLA calculation was based on the effluent limits included in the surface

water discharge permit, multiplied by the 80th percentile maximum flow rate. The normal operation of these systems would typically result in only a small portion of the calculated daily amounts actually being discharged. It is important to note all discharges are required to meet the chronic water quality thresholds (standard) for the West Fork of the Vermillion River.

Including the WLA in the load duration curve required several factors be taken into account. The maximum (total or sum) fecal coliform waste load for four systems is 4.05×10^{11} cfu/day coupled with a total or sum flow of 8.27 cfs. A flow of 8.27 cfs is met or exceeded in the West Fork of the Vermillion River only 31% of the time, i.e. 69 % of the time the river discharge falls below this flow level. Arbitrarily adding this load to the entire flow regime would be a misrepresentation of how these five intermittent wastewater systems function and over emphasizing their impact on the load capacity. This calculation implies a continuous discharge when, in fact, discharge occurs 1-3 times per year. All facilities generally discharge outside of the recreation season (May 1 through September 30) when the limited contact beneficial use does not apply.

The city of Canistota, SD discharges 2-3 times per year. Discharges are typically outside the recreation season. When they do discharge during the recreation season, bacteria samples results are normally well below the limit, although one (in ten years) was above the limit.

The city of Howard, SD generally discharges in the spring and fall. There have been five discharges during the recreation season in the last five years. This WWTF is not required to monitor fecal as they discharge to an intermittent portion of the West Fork of the Vermillion River approximately 15 miles upstream of Segment R9. The waste load was not included in Segment R9.

Marion generally discharges a couple of times a year, occasionally in the recreation season (59%). No fecal sample results have been above the limits. Most have been well below the limits.

Parker discharges once or twice a year and periodically discharges during the recreation season. All fecal sample results have been well below the limits (Table 7).

Salem discharges about once a year. All but one of the discharges during the last ten years have been during the recreation season. The highest fecal sample result was 130 but most are around ten.

E.coli was recently added to the water quality standards and is not included in the current surface water discharge permits. The WLA for *E. coli* was calculated by multiplying the threshold of the chronic standard (630 cfu/100ml) by the allowable flow rate from each of the facilities in Table 7 specified in the current WLAs for fecal coliform. When the current permit expires, the fecal coliform WLA will be replaced with a WLA for *E. coli*. The new permits will likely provide an *E. coli* load allocation of 4.01×10^{11} cfu/100ml assuming the same flow rate. This load is based on the chronic standard and was used as a reasonable WLA for the *E.coli* TMDL. The *E.coli* wasteload contributed by these five treatment facilities are also insignificant and not contributing to the impairment of the classified segment of the West Fork of the Vermillion River.

Table 8. Discharge Monitoring Report Data for Five WWTF in the West Fork Watershed.

Facility	Total # of Discharges over last 5 year	# of Discharges within recreation Season	% of Dischargers within recreation season	Avg. Concentration of available fecal Daily Max Samples (cfu/100ml)
Canistota	15	5	33%	93
Howard	9	5	56%	n/a
Marion	22	13	59%	362
Parker	2	2	100%	none available
Salem	4	0	0%	10
Total	52	25	48%	

Flow data used to develop the flow frequency curve includes daily flow data. The flow record provided over 50 years of daily flow data which included all wastewater treatment facility discharges during that time period. The flow variability, as a result of the intermittent operation of these facilities, is fully accounted for in the flow frequency curve.

6.2 Nonpoint Sources

Nonpoint sources of fecal coliform bacteria from the West Fork of the Vermillion River come primarily from agricultural sources. County wide livestock data, from the 2007 and 2009 National Agricultural Statistic Survey (NASS), and wildlife data, from the 2002 South Dakota Game Fish and Parks county wildlife assessment, were used to derive density estimates for livestock and wildlife densities, respectively.

Statistically derived livestock estimates (beef cattle, hogs, etc.) from the NASS 2007 Agricultural Census was used for each county involved in the Segment R9 watershed (Appendix B). Livestock animals per acre for each county were then multiplied by the acres from each county within the watershed. Table 11 shows the acres of Segment R9 watershed that are located within each county. The animals listed in Table 11 (wildlife and livestock) are the largest animals and most densely populated within the involved counties (McCook, Hutchinson, Miner, Turner). The density estimates were then multiplied by the acres of Segment R9 watershed found within each county, which is also found in Table 11.

The animal density information was used to estimate relative source contributions of bacteria loads. For example, based on the 2007 density estimates there were 425 dairy cows in the watershed resulting in an estimated 3.17E+13 cfus per day (425 cows X 7.45E+10 cfus). Daily outputs from each animal type were taken from the reference worksheet found on the Bacterial Indicator Tool (BIT). The EPA BIT tool is a spreadsheet that estimates the bacteria contribution from multiple sources.

Human inputs were determined through several GIS county wide feature datasets provided by the SD Dept. of Transportation (SDDOT). The dataset was used primarily for assessing county roads and structures along roads, such as rural residences (both occupied and unoccupied), were documented. The number of occupied residences for the acres of watershed within each county

were used to estimate how many septic tanks were located in the watershed in each county. It was assumed on average that each residence contained two people. It was assumed that 25% of these septic tanks were failing. The daily human output of 1.88E+11 fecal coliform per human was taken from the BIT Tool Reference worksheet which lists the USGS as the source of the human output estimate (EPA BIT tool). The total estimate of 6.84E+13 fecal coliform from humans was used in Table 10 and Table 11.

Table 9. Human Input Estimates

County	Occupied
McCook	207
Hutchinson	55
Miner	151
Turner	292
Total Occupied Residences	727
# per household	2
Total Population	1454
25% Failure Rate for Septic Tank	0.25
USGS Human Daily Estimate	1.88E+11
Total Human Contribution	**6.84E+13**

6.2.1 Agriculture

Manure from livestock is a potential source of fecal coliform to the stream. Livestock in the basin are predominantly hogs and beef cattle. Livestock can contribute fecal coliform bacteria directly to the stream by defecating while wading in the stream. They also can contribute by defecating while grazing on rangelands which is washed off during precipitation events. Table 10 allocates the sources for bacteria production in the watershed into four primary categories. The summary is based on several assumptions. Feedlot numbers were calculated as the sum of all dairy, hog, and the NASS estimate of beef in feeding areas. All remaining livestock were assumed to be on grass.

Table 10. Fecal and *E. coli* Source Allocations for the West Fork of the Vermillion River.

Source	Percentage
Feedlots	77.0%
Livestock on Grass	8.5%
Wildlife	2.2%
Septic Tanks	5.6%

The main source of fecal coliform and *E. coli* bacteria in the West Fork watershed is livestock from a combination of feedlots and grazing. Bacteria migration from feedlots and upland grazing is most likely occurring during major run-off events. Direct use of the stream by livestock is the most likely source of bacteria at low flows. Evidence of this is available in the load duration curves which indicate that elevated counts of Fecal coliform and *E. coli* occur throughout different flow regimes. Beef cattle and hogs were found to contribute the most significant amount of bacteria to the West Fork of the Vermillion River (Table 11).

6.2.2 Human

There are five separate point sources within the West Fork of the Vermillion River watershed which were previously described. Failing onsite septic systems are assumed to be the primary human source not served by the POTW within the watershed. Human fecal production was estimated at 1.88E+11 (Bacterial Indicator Tool Reference Worksheet - USGS estimate). When included as a total load in the table, the remaining population accounted for about 5.6% of all fecal coliforms/*E. coli* produced in the watershed assuming a 25% failure rate for the onsite wastewater systems.

6.2.3 Natural background/wildlife

Wildlife within the watershed is a natural background source of fecal coliform and *E. coli* bacteria. Wildlife population density estimates were obtained from the South Dakota Department of Game, Fish, and Parks (Table 11). The contribution of bacteria from wildlife in the West Fork watershed was insignificant (2.2%) in comparison to livestock sources.

Table 11. West Fork of the Vermillion River Potential Nonpoint Sources

Animal Type	FC (#/animal/day)	Type Used for Estimate	HUTCHINSON (animals/acre)	KINGSBURY (animals/acre)	MCCOOK (animals/acre)	MINER (animals/acre)	TURNER (animals/acre)
CATTLE, ON GRASS	4.57E+09	Cow	0.1016	0.1089	0.0961	0.0938	0.0676
CATTLE, COWS, MILK	7.45E+10	Dairy Cow	0.0056	0.0011	0.0077	0.0019	0.0163
CATTLE, ON FEED - IN	7.27E+10	Beef Cow	0.0232	0.0425	0.0175	0.0129	0.0403
CHICKENS, BROILERS -	1.81E+08	Broilers	0.0000	0.0004	0.0027	0.0003	0.0001
CHICKENS, LAYERS - IN	1.37E+08	Layers	0.0015	0.0000	0.0045	0.0005	0.0013
EQUINE, HORSES & PO	2.59E+10	Horse	0.0009	0.0011	0.0018	0.0010	0.0019
GOATS - INVENTORY	1.66E+10	Sheep	0.0004	0.0000	0.0000	0.0000	0.0003
HOGS - INVENTORY	1.02E+10	Hog	0.2251	0.0162	0.1658	0.0364	0.1554
SHEEP, INCL LAMBS - I	1.66E+10	Sheep	0.0057	0.0101	0.0111	0.0108	0.0333
TURKEYS - INVENTOR	1.04E+08	Turkey (Wild	0.5522	0.1140	0.0000	0.0001	0.0001
Badger	1.25E+08	Raccoon	0.0013	0.0029	0.0019	0.0009	0.0014
Beaver	2.50E+08	Beaver	0.0023	0.0006	0.0015	0.0014	0.0028
Cottontail Rabbit	1.25E+08	Raccoon	0.0134	0.0384	0.0177	0.0495	0.0127
Coyote	4.09E+09	Dog	0.0017	0.0014	0.0010	0.0021	0.0013
Fox	1.25E+08	Raccoon	0.0018	0.0019	0.0030	0.0009	0.0018
Jackrabbit	1.25E+08	Raccoon	0.0033	0.0086	0.0052	0.0220	0.0009
Mink	2.50E+07	Muskrat	0.0013	0.0054	0.0045	0.0047	0.0019
Muskrat	2.50E+07	Muskrat	0.0024	0.0144	0.0136	0.0149	0.0020
Nest Canada Geese	4.90E+10	Goose	0.0011	0.0009	0.0020	0.0019	0.0013
Opossum	1.25E+08	Raccooon	0.0023	0.0038	0.0033	0.0033	0.0030
Partridge	1.37E+08	Layers	0.0017	0.0115	0.0041	0.0033	0.0006
Raccoon	1.25E+08	Raccoon	0.0057	0.0115	0.0061	0.0138	0.0058
Skunk	1.25E+08	Raccoon	0.0029	0.0157	0.0060	0.0110	0.0035
Squirrel	1.25E+08	Raccoon	0.0023	0.0067	0.0218	0.0206	0.0203
Turkey	1.04E+08	Turkey (Wild	0.0009	0.0000	0.0000	0.0000	0.0006
Whitetail Deer	5.00E+08	Deer	0.0027	0.0073	0.0082	0.0083	0.0043
		Acres in Segment R9 Watershed	9,878	9,759	97,821	62,873	70,680
Bacteria Indicator Tool Reference Worksheet used for each estimate							

Table 11. cont.

Source	Total Contribution	Percent Contribution
Cattle on Grass	1.04E+14	8.5%
Beef Cattle on Feed	4.49E+14	36.6%
Dairy Cow	1.60E+14	13.0%
Chickens, Turkeys, Goats	1.31E+12	0.1%
Hogs	3.36E+14	27.3%
Sheep	7.29E+13	5.9%
Horses	1.06E+13	0.9%
All Wildlife	2.67E+13	2.2%
Septic Tanks	6.84E+13	5.6%
Total	1.23E+15	100%

6.2.4 Tributary Contributions

The West Fork of the Vermillion River has several smaller unnamed tributaries which drain intermittently. These tributaries drain portions of Kingsbury, Miner, McCook and Turner Counties (Figure 1). The significance of these smaller intermittent streams on the West Fork of the Vermillion was not determined. Most loadings occur along the length of the West Fork and drain directly to it.

7.0 Linkage Analyses

7.1 Load Duration Curve Analysis

Both the fecal coliform and *E. coli* TMDL were developed using a Load Duration Curve (LDC) approach resulting in a flow-variable target that considers the entire flow regime. In the West Fork of the Vermillion River, Figures 3 and 4 show violations occurring throughout the flow duration curve. The LDC approach was deemed an appropriate method for identifying possible sources of bacteria based on the flow zone.

The LDC is a dynamic expression of the allowable load for any given day. To aid in interpretation and implementation of the TMDL, the LDC flow intervals were grouped into four flow zones representing high flows (0–10 percent), moist conditions (10-40 percent), mid-range flows (40–60 percent), and dry/low conditions (60–100 percent) according to EPA's *An Approach for Using Load Duration Curves in the Development of TMDLs* (USEPA, 2006). The ranges for these four zones were based on 50 years of flow data (1961-2011), five years of sampling data collected from Vermillion River as part of the watershed assessment. There is no WQM Site for the Section 106 ambient monitoring program on this segment.

For the West Fork of the Vermillion River instantaneous loads were calculated by multiplying the fecal coliform and *E. coli* concentrations collected from SD DENR TMDL Site VRWF15 and VRWF20 by the daily average flow (USGS Gage No. 06478690), and a units conversion factor.

When the instantaneous loads are plotted on the LDC, characteristics of the water quality impairment are shown. Instantaneous loads that plot above the curve are exceeding the TMDL, while those below the curve are in compliance. As the plot shows, pathogen samples collected from the West Fork of the Vermillion River exceed the daily maximum criterion within each zone (Figures 6 and 7). Loads exceeding the criteria in the high flow zones imply storm runoff from animal feeding operations or storm sewer runoff. Loads shown in the low flow zone typically indicate point source load or livestock defecating in the stream contributions.

South Dakota recently adopted *Escherichia coli* criteria for the protection of limited contact and immersion recreation uses. The West Fork of the Vermillion River requires an *E. coli* TMDL because the parameter was listed as a cause of impairment to this stream on the 303(d) list of impaired waterbodies in the 2010 and 2012 IR. Because the two indicators are closely related, the fecal coliform bacteria sources and associated implementation strategy described in this document are expected to apply to both the fecal coliform bacteria and *E. coli* impairments. This TMDL document incorporates a TMDL for both parameters.

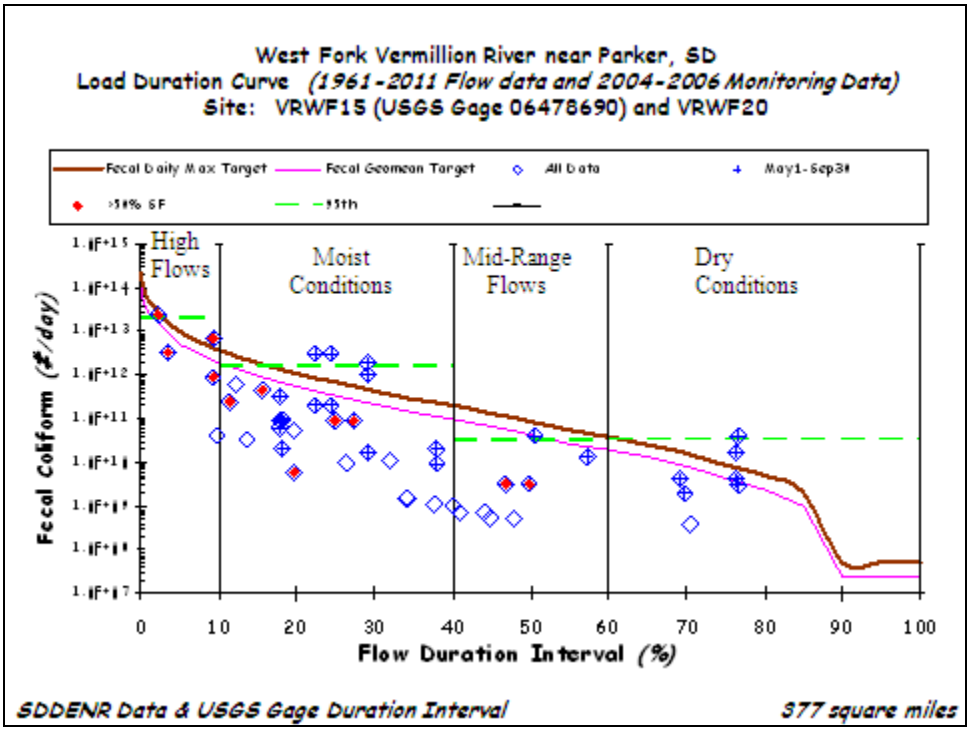

Figure 6. Segment R9 – Fecal Coliform Load Duration Curve, West Fork of the Vermillion River. Load duration curve representing allowable daily fecal coliform loads based on the geometric mean and daily maximum criteria (≤1,000 cfu/100ml and ≤2,000 cfu/100ml, respectively). Plot showing median and 95th percentiles, and daily loads for each flow zone. The geometric mean (1,000 cfu/100ml) was used to determine the loading capacity for the Segment R2 and the TMDL. Observed concentrations are also displayed.

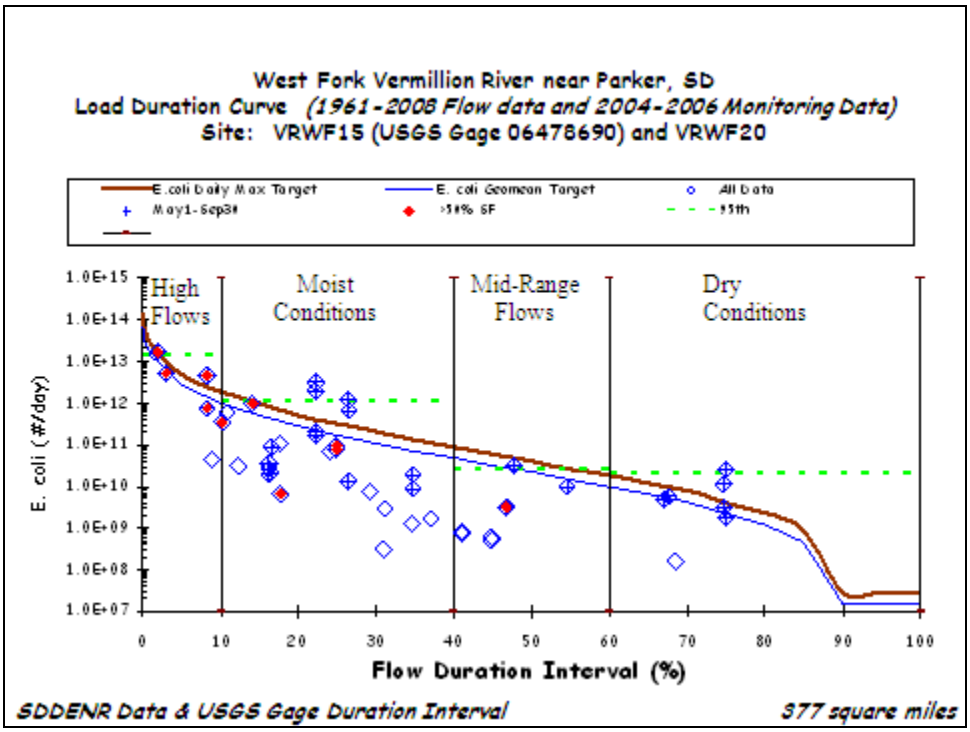

Figure 7. ***Escherichia coli*** **Load Duration Curve, West Fork of the Vermillion River.**

8.0 TMDL Allocations – Fecal Coliform

The flow frequency curve generated for the West Fork of the Vermillion River characterizes the system as perennial with significant flow occurring approximately 90% of the time (Figure 6). Flow zones were defined according to the flow regime structure and distribution of the observed data following guidance recommended by EPA (USEPA, 2001). Four distinct flow zones were established to facilitate interpretation of the hydrologic conditions and patterns associated with the impairment. The zones were segmented by extreme flows (0-10 percent), high to moderate flows (10-40 percent), mid-range flows (40-60 percent) and low to dry flows (60-100 percent).

Flows in the high zone are extremely variable ranging from a maximum of 4,410 cfs to a low of 78 cfs. Flows represented in this zone occur on an infrequent basis and are characteristic of significant run-off events. Of the five fecal coliform samples available for this flow zone only the maximum sample of 3,200 cfu/100ml exceeded both the acute and chronic standard. The current load for the high flow zone was calculated 95th percentile from the five samples and the 95th percentile flow for this zone. All components of the TMDL for the high flow zone including the current load and calculated reductions are presented in Table 12.

The high to moderate flow zone includes flows that range from 78.0 cfs to 4.0 cfs. Flows in this zone are likely generated from moderate to small run-off events. The fecal coliform samples collected in this flow zone ranged from a high concentration of 8,700 cfu/100ml to 10 cfu/100ml.

Twenty-four samples were collected in the moderate zone of which three exceeded the acute standard and chronic standard. All components of the TMDL for the moderate flow zone including the current load and calculated reductions are presented in Table 12.

The mid-range flow zone includes flows that range from 4.0 cfs to 0.78 cfs. Flows from this zone are base flows resulting from decreased surface run-off and groundwater inputs. The fecal coliform samples collected in this zone display little variability ranging from a high of 920 cfu/100ml to 10 cfu/100ml. Seven samples were collected in this zone of which none exceeded the acute or chronic standard. The 95th percentile flow and fecal coliform concentration were used to calculate the current load. All components of the TMDL for the low flow zone including the current load and calculated reductions are presented in Table 12.

Flows in the low to dry zone ranged from 0.78 cfs to 0.0 cfs. Flows from this zone are during winter or drought conditions recorded over the last 50 years. Most frequently they occur during winter months. Seven samples were collected within this zone of which two exceeded the acute and chronic standards. The maximum concentration of 12,000 cfu/100ml observed from this site was collected in this flow zone. The 95th percentile flow and fecal coliform concentration were used to calculate the current load. All components of the TMDL for the low flow zone including the current load and calculated reductions are presented in Table 12.

The chronic standard ($\leq$ 1000 cfu/100ml) was used to develop the TMDLs for each distinct flow zone to be protective and provide assurance that neither water quality standard will be exceeded. The 95th percentile concentration was used to calculate current loadings and associated reductions for the moderate and low flow zones to allow for variability in the small datasets. The relatively high fecal coliform concentrations and associated exceedance rate of the acute and chronic standard across flow zones suggests that the source is continual. The most significant source of fecal coliform bacteria produced in the watershed is from beef livestock and hogs with over 70% residing in confinement operations. The WLA provides a relatively large portion of the allocation because it is based on permit levels that, although the WWTFs operate intermittently, assume continuous discharge. The most likely source of fecal coliform contamination to the West Fork of the Vermillion River is run-off from feedlot operations especially in the high and moderate flow zones with livestock grazing in the lower end of the moderate and low flow zone.

The LDC (Table 12 and Figure 6) represents the dynamic expression of the fecal coliform TMDL for Segment R9, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed load reductions, Table 12 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from May 1 through September 30 and is based on daily flow and the chronic (30-day geometric mean) water quality standard.

Table 12. Segment R9 – Fecal Coliform Total Maximum Daily Load (TMDL) allocations by flow zone (Site VRWF15 and USGS Gage 06478690).

Station ID:	**DENR TMDL Site VRWF15 and VRWF22**			
Station name:	**USGS Gaging (06478690) near Parker, SD**			
Parameter of Concern	**Flow Zone (expressed as tons/day)**			
Fecal Coliform	**Extreme Flows (0-10%)**	**High-Range (10-40%)**	**Mid Range Flows (40-60%)**	**Low Flows (60-100%)**
Flow Range	**>78 cfs**	**78 - 4 cfs**	**4 - 0.78 cfs**	**<0.78 cfs**
Median Flow Per Zone	206.0	14.0	1.8	0.10
95%tile Flow Per Zone	1580.0	62.0	3.8	0.7
Load Allocation	3.44E+13	9.60E+11	4.18E+10	7.27E+09
WLA - CANISTOTA, SD	3.18E+10	3.18E+10	3.28E+09	5.70E+08
WLA - HOWARD, SD	0	0	0	0
WLA - MARION, SD	1.47E+11	1.47E+11	1.52E+10	2.63E+09
WLA - MONROE, SD	0	0	0	0
WLA - PARKER, SD	1.39E+11	1.39E+11	8.99E+09	1.56E+09
WLA - SALEM, SD	8.71E+10	8.71E+10	1.44E+10	2.50E+09
MOS (10% Explicit)	4E+12	2E+11	9E+09	2E+09
TMDL	**3.87E+13**	**1.52E+12**	**9.30E+10**	**1.61E+10**
95th Percentile Load per Zone	2.09E+13	1.73E+12	3.23E+10	3.38E+10
Load Reduction	**-85.2%**	**12.4%**	**-188.0%**	**52.3%**
95th Percentile Concentration Per Zone	2,920	7,075	809	9,780
Number of Values	5	24	7	7
Number of Values exceeding 2,000 CFUs/100ml	1	3	0	2
Current Load or existing Condition is the 95th Percentile of the observed fecal coliform Loads for each flow zone.				

8.1 Load Allocation (LA) – Fecal Coliform

To develop the fecal coliform load allocation (LA), the loading capacity (LC) was first determined. The LC for Segment R9 (Vermillion River to McCook-Miner County Line) was calculated by multiplying the 30-day geometric mean (1,000 cfus/100ml) criterion by the daily average flow measured at the USGS gage 06478690 which was also monitoring site VRWF15 approximately 3 miles northwest of Parker, SD. Site VRWF15 is the most downstream site within this segment. There were four mainstem sites located on the West Fork of the Vermillion River but only two were found within Segment R9 (Site VRWF15 and VRWF20).

The threshold of the 30-day geometric mean (1,000 cfus/100ml) was used for the calculation of the LC, rather than the daily maximum threshold (2,000 cfus/100ml) because the chronic is considered more protective. The 30-day geometric mean, as defined in ARSD § 74:51:01:01, is "the nth root of a product of n factors". As part of the criteria for the beneficial use (8) limited contact recreation the geometric mean is "based on a minimum of five samples obtained during separate 24-hour periods for any 30-day period, and they may not exceed this value in more than 20 percent of the samples examined in this same 30-day period" (ARSD § 74:51:01:51). The

30-day geometric mean criteria applies only seasonally from May 1 through September 30. Compliance can only be determined when a minimum of five samples are obtained during separate 24-hour periods for any 30-day period. In many instances, only one or two samples were collected during any 30-day period, so the threshold rather than criterion was applied to each flowzone in Figure 6. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the geometric mean threshold to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data would be needed to accurately assess compliance with the 30-day geometric mean criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 95th percentile of the range of LCs within a zone was set as the flow zone goal. Fecal coliform loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 95th percentile, while using the geometric mean (1,000 cfus/100ml) criterion within each flowzone will protect the limited contact recreation beneficial use under all but the most extreme circumstances and is a conservative assumption (Figure 6).

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

8.2 Waste Load Allocation (WLA)

There are five facilities or NPDES Permit holders located along Segment R9. Each of these wastewater treatment facilities are comprised of retention pond systems that may periodically require a portion of the final pond to be discharged. The wasteload allocations were set equal to the discharge of the final pond in the system for the two highest flowzones. Based on a cumulative total flow of 8.27 cfs and a fecal coliform concentration of 1,000 cfu/100ml in accordance with the NPDES/Surface Water Discharge permit. For the two lower flowzones the WLA was adjusted to fit the flow range by splitting the allocations proportionately (percent contribution of each WWTF flow to the total WLA flow) between the LA and WLA taking into account the MOS. This resulted in a flow of 1.71 cfs and 0.297 cfs for the lower two flow zones and a concentration of 1,000 cfu/100ml, respectively.

The WLA ensures that water quality standards for both fecal coliform and *E. coli* will be attained. Operation of these systems is conducted in a manner so that discharges are short in duration (several days to two weeks) one or two times per year. They do not provide a continuous discharge to the stream and account for significantly less than 1% of the annual water load, collectively as well as individually. Each WLA was included in the flow zone as a part of the daily load. The WLA in the lower two flow zones would account for 43% and 38% of the maximum flow within each flow zone, respectively. If all four facilities discharged at the same time, during the recreation season, the West Fork of the Vermillion River would be an effluent dominated stream. However, bacteria concentrations from the effluent are likely to be an order of magnitude less than the permit limit allowing for additional NPS load allocation in the overall

load capacity. In addition, if the flow is at or above 8.27 cfs, which is the total flow used in the WLAs, then the receiving stream would shift to a higher flow regime of the TMDL. When flow in the two lower zones is not effluent driven the WLA can be considered solely included as LA in the overall load capacity.

All the NPDES facilities identified in these TMDLS have mechanisms in place that reduce fecal coliform and E. coli bacteria. Bacteria in the wastewater lagoons and ponds are viable for short periods due to extended retention time and resultant exposure to the ultraviolet light. This is evident in the bacteria data collected required by the permit. The relative assumption is fecal coliform and E. coli bacteria contributions from the Scotland facility are minor and not causing impairment. Emphasis should be placed on reducing bacteria inputs from livestock sources (feedlots and grazing) to bring the recreational use of the classified segment of the West Fork of the Vermillion River into compliance.

9.0 TMDL Allocations – *E. coli*

The flow frequency curve generated for the West Fork of the Vermillion River characterizes the system as perennial with significant flow occurring approximately 90% of the time (Figure 4). Flow zones were defined according to the flow regime structure and distribution of the observed data following guidance recommended by EPA (USEPA, 2001). Four distinct flow zones were established to facilitate interpretation of the hydrologic conditions and patterns associated with the impairment. The zones were segmented by extreme flows (0-10 percent), high to moderate flows (10-40 percent), mid-range flows (40-60 percent) and low to dry flows (60-100 percent).

Flows in the high zone are extremely variable ranging from a maximum of 4,410 cfs to a low of 78 cfs. Flows represented in this zone occur on an infrequent basis and are characteristic of significant run-off events. Of the five *E. coli* samples available for this flow zone two samples exceeded both the acute and chronic standard (2,178 cfu/100ml and 1,285 cfu/100ml). The current load for the high flow zone was calculated 95th percentile from the five samples and the 95th percentile flow for this zone. All components of the TMDL for the high flow zone including the current load and calculated reductions are presented in Table 13.

The high to moderate flow zone includes flows that range from 78.0 cfs to 4.0 cfs. Flows in this zone are likely generated from moderate to small run-off events. The *E. coli* samples collected in this flow zone ranged from a high concentration of 5,451 cfu/100ml to 2 cfu/100ml. Twenty-four samples were collected in the moderate zone of which three exceeded the acute standard and chronic standard. All components of the TMDL for the moderate flow zone including the current load and calculated reductions are presented in Table 13.

The mid-range flow zone includes flows that range from 4.0 cfs to 0.78 cfs. Flows from this zone are base flows resulting from decreased surface run-off and groundwater inputs. The *E. coli* coliform samples collected in this zone display little variability ranging from a high of 695 cfu/100ml to 11 cfu/100ml. Seven samples were collected in this zone of which only one exceeded the acute or chronic threshold. The 95th percentile flow and fecal coliform concentration were used to calculate the current load. All components of the TMDL for the low flow zone including the current load and calculated reductions are presented in Table 13.

Flows in the low to dry zone ranged from 0.78 cfs to 0.0 cfs. Flows from this zone are during winter or drought conditions recorded over the last 50 years. Most frequently they occur during the winter months. There seven samples collected within this zone of which two exceeded the acute and chronic threshold. The maximum concentration of 7,320 cfu/100ml was calculated from the regression equation would be in this flow zone. The 95th percentile flow and *E. coli* concentration were used to calculate the current load. All components of the TMDL for the low flow zone including the current load and calculated reductions are presented in Table 13.

The chronic threshold ($\leq$ 630 cfu/100ml) was used to develop the TMDLs for each distinct flow zone to be protective and provide assurance that neither water quality standard will be exceeded. The 95th percentile concentration was used to calculate current loadings and associated reductions for the moderate and low flow zones to allow for variability in the small datasets. The relatively high fecal coliform and *E. coli* concentrations and associated exceedance rate of the acute and chronic thresholds across flow zones suggests that the source is continual. The most significant source of bacteria produced in the watershed is from beef livestock and hogs with over 70% residing in confinement operations. The WLA provides a relatively large portion of the allocation because it is based on permit levels that, although the WWTFs operate intermittently, assume continuous discharge. The most likely source of *E. coli* contamination to the West Fork of the Vermillion River is run-off from feedlot operations especially in the high and moderate flow zones with livestock grazing in the lower end of the moderate and low flow zone.

The LDC (Table 13 and Figure 7) represents the dynamic expression of the *E. coli*. TMDL for Segment R9, resulting in a unique maximum daily load that corresponds to a measured average daily flow. To aid in the implementation of the TMDL and estimation of needed load reductions, Table 13 presents a combination of allocations for each of four flow zones. Methods used to calculate the TMDL components are discussed below. This TMDL is in effect from May 1 through September 30 and is based on daily flow and the chronic (30-day geometric mean) threshold.

Table 13. Segment R9 – *Escherichia Coliform* Total Maximum Daily Load (TMDL) allocations by flow zone (Site VRWF15 and USGS Gage 06478690).

Station ID:	**DENR TMDL Site VRWF15 and VRWF22**			
Station name:	**USGS Gaging (06478690) near Parker, SD**			
Parameter of Concern	**Flow Zone (expressed as cfus/day)**			
E. Coli	**Extreme Flows (0-10%)**	**High-Range (10-40%)**	**Mid Range Flows (40-60%)**	**Low Flows (60-100%)**
Flow Range	**>78 cfs**	**78 - 4 cfs**	**4 - 0.78 cfs**	**<0.78 cfs**
Median Flow Per Zone	206.0	14.0	1.8	0.10
95%tile Flow Per Zone	1580.0	62.0	3.8	0.66
Load Allocation	2.17E+13	6.22E+11	2.64E+10	4.58E+09
WLA - CANISTOTA, SD	1.87E+10	1.87E+10	2.07E+09	3.59E+08
WLA - HOWARD, SD	0	0	0	0
WLA - MARION, SD	8.65E+10	8.65E+10	9.56E+09	1.66E+09
WLA - MONROE, SD	0	0	0	0
WLA - PARKER, SD	5.13E+10	5.13E+10	5.67E+09	9.84E+08
WLA - SALEM, SD	8.20E+10	8.20E+10	9.06E+09	1.57E+09
MOS (10% Explicit)	2E+12	1E+11	6E+09	1E+09
TMDL	**2.44E+13**	**9.56E+11**	**5.86E+10**	**1.02E+10**
95th Percentile Load per Zone	1.49E+13	1.14E+12	2.45E+10	2.09E+10
Load Reduction	**-63.2%**	**16.5%**	**-139.1%**	**51.3%**
95th Percentile Concentration Per Zone	2,000	4,503	616	6,036
Number of Values	5	24	7	7
Number of Values exceeding 1,178 CFUs/100ml	2	3	0	2
Current Load or existing Condition is the 95th Percentile of the observed *E. coli* Loads for each flow zone.				

9.1 Load Allocation (LA)

To develop the *E. coli* load allocation (LA), the loading capacity (LC) was first determined. The LC for Segment R9 (Vermillion River to McCook-Miner County Line) was calculated by multiplying the 30-day geometric mean (630 cfus/100ml) criterion by the daily average flow measured at the USGS gage 06478690 which was also monitoring site VRWF15 approximately 3 miles northwest of Parker, SD. Site VRWF15 is the most downstream site within this segment. There were four mainstem sites located on the West Fork of the Vermillion River but only two were found within this segment (Site VRWF15 and VRWF20).

The threshold from 30-day geometric mean (630 cfus/100ml) was used for the calculation of the LC, rather than the daily maximum (1,178 cfus/100ml) because the chronic threshold is considered more protective. The 30-day geometric mean, as defined in ARSD § 74:51:01:01, is "the nth root of a product of n factors". As part of the criteria for the beneficial use (8) limited contact recreation the geometric mean is "based on a minimum of five samples obtained during separate 24-hour periods for any 30-day period, and they may not exceed this value in more than 20 percent of the samples examined in this same 30-day period" (ARSD § 74:51:01:51). The 30-day geometric mean criteria apply only seasonally from May 1 through September 30. Compliance can only be determined when a minimum of five samples are obtained during separate 24-hour periods for any 30-day period. In many instances, only one or two samples

were collected during any 30-day period, so the criterion was applied to each flowzone in Figure 7. Although the daily maximum criteria are exceeded, to be conservative it was decided to use the geometric mean threshold to develop the loading capacity of the stream in order to ensure that the most stringent water quality standards are met. Additional data would be needed to accurately assess compliance with the 30-day geometric mean criterion. The loading capacities and reductions derived from the available data are estimates (i.e., the calculated loading capacities and reductions may be higher or lower if/when a more extensive data set is collected to fully assess compliance with the chronic standard). For each of the four flow zones, the 95th percentile of the range of LCs within a zone was set as the flow zone goal. *E. coli* loads experienced during the largest stream flows (e.g. top 5 percent) cannot be feasibly controlled by practical management practices. Setting the flow zone goal at the 95th percentile, while using the geometric mean (630 cfus/100ml) threshold within each flowzone will protect the limited contact recreation beneficial use under all but the most extreme circumstances and is a conservative assumption (Figure 7).

Portions of the LC were allocated to point sources as a waste-load allocation (WLA) and nonpoint sources as a load allocation (LA). A fraction of the LC was also reserved as a margin of safety (MOS) to account for uncertainty in the calculations of these load allocations. The method used to calculate the MOS is discussed below. The LA was determined by subtracting the WLA and MOS from the LC. Thus, the TMDL (and LC) is the sum of WLA, LA, and MOS.

9.2 Waste Load Allocation (WLA)

There are five facilities or NPDES Permit holders located along Segment R9. Each of these wastewater treatment facilities are comprised of retention pond systems that my periodically require a portion of the final pond to be discharged. The wasteload allocations were set equal to the discharge of the final pond in the system for the two highest flow zones. Based on a cumulative total flow of 8.27 cfs and a fecal coliform concentration of 630 cfu/100ml in accordance with the NPDES/Surface Water Discharge permit. For the two lower flowzones the WLA was adjusted to fit the flow range by splitting the allocations proportionately (percent contribution of each WWTF flow to the total WLA flow) between the LA and WLA taking into account the MOS. This resulting in a flow of 1.71 cfs and 0.297 cfs for the lower two flow zones and a concentration of 630 cfu/100ml, respectively.

The WLA ensures that water quality standards for both fecal coliform and *E. coli* will be attained. Operation of these systems is conducted in a manner so that discharges are short in duration (several days to two weeks) one or two times per year. They do not provide a continuous discharge to the stream and account for significantly less than 1% of the annual water load, collectively as well as individually. Each WLA was included in the flow zone as a part of the daily load. The WLA in the lower two flow zones would account for 43% and 38% of the maximum flow within each flow zone, respectively. If all four facilities discharged at the same time, during the recreation season, the West Fork of the Vermillion River would be an effluent dominated stream. However, bacteria concentrations from the effluent are likely to be an order of magnitude less than the permit limit allowing for additional NPS load allocation in the overall load capacity. In addition, if the flow is at or above 8.27 cfs, which is the total flow used in the WLAs, then the receiving stream would shift to a higher flow regime of the TMDL. When flow

in the two lower zones is not effluent driven the WLA can be considered solely included as LA in the overall load capacity.

All the NPDES facilities identified in these TMDLS have mechanisms in place that reduce fecal coliform and E. coli bacteria. Bacteria in the wastewater lagoons and ponds are viable for short periods due to extended retention time and resultant exposure to the ultraviolet light. This is evident in the bacteria data collected required by the permit. The relative assumption is fecal coliform and E. coli bacteria contributions from the Scotland facility are minor and not causing impairment. Emphasis should be placed on reducing bacteria inputs from livestock sources (feedlots and grazing) to bring the recreational use of the classified segment of the West Fork of the Vermillion River into compliance.

10.0 Margin of Safety (MOS)

In accordance with the regulations, a margin of safety was established to account for uncertainty in the data analyses. A margin of safety may be provided (1) by using conservative assumptions in the calculation of the loading capacity of the waterbody and (2) by establishing allocations that in total are lower than the defined loading capacity. In the case of the West Fork of the Vermillion River, the latter approach was used to establish a safety margin for both the fecal coliform and *E. coli* TMDLs.

An 10% explicit MOS was calculated within the duration curve framework to account for uncertainty (e.g., loads from tributary streams, effectiveness of controls, etc.). This 10% explicit MOS was calculated from the TMDL within each flowzone and reserved as unallocated assimilative capacity. The remaining assimilative capacity was attributed nonpoint sources (LA) or point sources (WLA).

As new information becomes available and the TMDL is revisited, this unallocated capacity may be attributed to nonpoint sources and added to the load allocation, or the unallocated capacity may be attributed to point sources and become part of the waste load allocation.

11.0 Seasonal Variation

Discharge in the West Fork of the Vermillion River (USGS gage# 06478690 near Parker, SD) displayed seasonal variation for the period of record (10/1/61 to 9/30/11). Highest stream flows typically occur during spring with highest monthly average stream flow reported in April (4,410 cfs), and lowest stream flows occur during the winter months with lowest monthly average stream flow reported in January (427.0 cfs). Although there is some relation to flow with most of the higher concentrations in the high flow zones occurring during spring and summer storm events. The lower flow zones displayed seasonal variation in concentrations possibly due to cattle grazing in the summer during lower flow periods where they access the stream to cool and drink. By using the LDC approach to develop the TMDL allocations, seasonal variability due to storm events or summer low flow periods is taken into account.

These TMDLs exclusively address the recreational season which is defined as May 1 through September 30. Additional bacteria (fecal coliform and *E.coli*) samples were collected outside the recreation season upstream of the classified segment and throughout the Vermillion River Basin during the watershed assessment.

12.0 Critical Conditions

Critical conditions occur within the basin during the spring and summer storm events. Typically, during severe thunderstorms the largest concentrations are highest in the basin during the summer months. Combined with the peak in grazing, high-intensity rainstorm events, which are common during the spring and summer, can produce significant amounts of sheet and rill erosion from animal feeding area. The excessive flows can transport waste material throughout the West Fork of the Vermillion and impair the recreational beneficial use.

13.0 Monitoring Strategy

During and after the implementation of management practices, monitoring will be necessary to assure attainment of the TMDL. Stream water quality monitoring will be accomplished through SD DENR's ambient water quality monitoring stations. The Vermillion River Basin has five permanent ambient stations which will sampled on a monthly basis.

Additional monitoring and evaluation efforts will be targeted toward the effectiveness of implemented BMPs. Sample sites will be based on BMP site selection and parameters will be based on a product-specific basis.

The Department may adjust the load and/or wasteload allocations in this TMDL to account for new information or circumstances identified during the implementation of the TMDL. If a review of the new information or circumstances indicates that an adjustment to the LA and WLA is appropriate than the TMDL will be updated following SDDENR programmatic steps including public participation. The Department will propose adjustments only in the event that any adjusted LA or WLA will not result in a change to the loading capacity and will reflect the water quality standards found in the ARSD. The Department will notify EPA of any adjustments to this TMDL within 30 days of their adoption.

14.0 Public Participation

Efforts taken to gain public education, review, and comment during development of the TMDL involved:

1. Monthly meetings were held during the assessment phase (2004-2006) through the Vermillion Basin Water Development District (VBWDD) which was the local sponsor for the TMDL project. Meetings minutes are available upon request.
2. A webpage was developed and used during the course of the assessment.
3. Presentations to local groups on the findings of the assessment.

4. 30-day public notice (PN) period for public review and comment.

The findings from these public meetings, the webpage, and 30-day PN comments have been taken into consideration in development of the previous Vermillion River Basin TMDLs as well as this TMDL targeting Segment R9.

15.0 Implementation

Currently, there is an implementation project targeting areas of sediment and bacterial sources within the Vermillion River Basin. During the next Section 319 funding round an increase in funding will be requested for additional BMPs targeting more areas of streambank erosion, animal waste management systems, and grazing management.

Several types of BMPs have been considered in the development of a water quality management implementation plan for the impaired segments of the Vermillion River Basin. The results shown in the Load Duration Curves indicate significant reductions are required in the both high flow and lower flow zones. Because of the rural area and the lack of point sources (WWTF) most of the implementation measures should focus on the following:

- Livestock access to streams should be reduced, and livestock should be provided sources of water away from streams.
- Unstable stream banks should be protected by enhancing the riparian vegetation that provides erosion control and filters runoff of pollutants into the stream.
- Filter strips should be installed along the stream bordering cropland and pastureland.
- Animal confinement facilities should implement proper animal waste management systems.
- An assessment of progress will be part of every Section 319 implementation segment, and revisions to the plan will be made as appropriate, in cooperation with basin stakeholders.

Funds to implement watershed water quality improvements can be obtained through SD DENR. SD DENR administers three major funding programs that provide low interest loans and grants for projects that protect and improve water quality in South Dakota. They include: Consolidated Water Facilities Construction program, Clean Water State Revolving Fund (SRF) program, and the Section 319 Nonpoint Source program.

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17.0 APPENDIX A: Water Quality Data

Site	Nearest Town	Date	Time	Event	Fecal Coliform (cfu/100mL)	logof fecal	E. Coli (/100mL)	E.Coli Translator	E. Coli to be used in TMDL	Flow (cfs)	Flow Rank
VRWF15	Parker	3/23/2005	11:00	Baseflow							
VRWF15	Parker	4/1/2005	14:45	Storm							
VRWF15	Parker	4/19/2005	14:45	Storm	30	1.4771	28		27.8	47	14%
VRWF15	Parker	5/10/2005	9:30	Baseflow	70	1.8451	55		55.0	10	29%
VRWF15	Parker	5/19/2005	11:30	Storm	410	2.6128	345		345.0	89	9%
VRWF15	Parker	6/6/2005	14:00	Storm	1800	3.2553		1286.2	1286.2	553	2%
VRWF15	Parker	6/29/2005	16:00	Baseflow	90	1.9542	37		36.8	29	18%
VRWF15	Parker	6/29/2005	16:20	Baseflow	130	2.1139	50		49.7	29	18%
VRWF15	Parker	9/22/2005	15:30	Baseflow	230	2.3617	687		687.0	0.35	70%
VRWF15	Parker	11/2/2005	16:00	Baseflow	50	1.6990		48.1	48.1	0.32	70%
VRWF15	Parker	1/26/2006	12:45	Spring Runoff	10	1.0000	19		18.7	6.2	34%
VRWF15	Parker	3/1/2006	13:15	Spring Runoff	10	1.0000		11.0	11.0	4.7	38%
VRWF15	Parker	3/15/2006	12:15	Spring Runoff	10	1.0000	2		2.0	6.3	34%
VRWF15	Parker	3/29/2006	15:00	Spring Runoff	10	1.0000		11.0	11.0	24	20%
VRWF15	Parker	4/13/2006	10:45	Storm	20	1.3010	22		21.6	81	10%
VRWF15	Parker	5/4/2006	16:00	Baseflow	30	1.4771		30.1	30.1	28	18%
VRWF15	Parker	5/30/2006	14:45	Baseflow	180	2.2553		155.7	155.7	4.6	38%
VRWF15	Parker	6/26/2006	14:15	Baseflow	550	2.7404		433.6	433.6	0.97	57%
VRWF15	Parker	7/25/2006	12:00	Storm	900	2.9542	526		526.0	0.14	77%
VRWF15	Parker	7/26/2006	12:30	Storm	1100	3.0414		818.8	818.8	0.15	76%
VRWF15	Parker	8/7/2006	14:45	Storm	70	1.8451		65.5	65.5	1.9	50%
VRWF15	Parker	9/5/2006	13:15	Storm	310	2.4914		256.3	256.3	12	27%
VRWF15	Parker	9/19/2006	11:00	Storm	580	2.7634		455.2	455.2	15	25%
VRWF15	Parker	11/20/2006	16:15	Baseflow	10	1.0000		11.0	11.0	3	44%
VRWF20	Salem	3/22/2005	11:00	Baseflow							
VRWF20	Salem	3/31/2005	11:00	Storm	160	2.2041	214		214.0	64	11%
VRWF20	Salem	4/18/2005	10:15	Storm	430	2.6335	397		397.0	58	12%
VRWF20	Salem	5/10/2005	10:45	Baseflow	4100	3.6128		2736.4	2736.4	10	29%
VRWF20	Salem	5/10/2005	10:45	Baseflow	7600	3.8808		4819.4	4819.4	10	29%

Site	Nearest Town	Date	Time	Event	Fecal Coliform (cfu/100mL)	logof fecal	E. Coli (/100mL)	E.Coli Translator	E. Coli to be used in TMDL	Flow (cfs)	Flow Rank
VRWF20	Salem	5/19/2005	15:00	Storm	3200	3.5051		2180.1	2180.1	89	9%
VRWF20	Salem	6/16/2005	12:00	Storm	430	2.6335	649		649.0	319	4%
VRWF20	Salem	6/29/2005	11:15	Baseflow	460	2.6628	28		27.5	29	18%
VRWF20	Salem	9/23/2005	8:30	Baseflow	460	2.6628	548		548.0	0.36	69%
VRWF20	Salem	1/31/2006	10:15	Spring Runoff	30	1.4771	214		214.0	13	26%
VRWF20	Salem	3/2/2006	12:00	Spring Runoff	10	1.0000	17		17.1	4	40%
VRWF20	Salem	3/16/2006	9:15	Spring Runoff	60	1.7782	42		41.6	7.6	32%
VRWF20	Salem	3/30/2006	10:45	Spring Runoff	520	2.7160	1050		1050.0	37	16%
VRWF20	Salem	4/24/2006	15:00	Storm	90	1.9542	192		192.0	24	20%
VRWF20	Salem	5/4/2006	17:15	Baseflow	150	2.1761		131.7	131.7	28	18%
VRWF20	Salem	5/30/2006	12:30	Baseflow	80	1.9031		74.0	74.0	4.6	38%
VRWF20	Salem	6/14/2006	10:30	Baseflow	920	2.9638		695.0	695.0	1.8	51%
VRWF20	Salem	7/25/2006	13:00	Storm	12000	4.0792		7326.8	7326.8	0.14	77%
VRWF20	Salem	7/26/2006	13:00	Storm	4600	3.6628		3041.0	3041.0	0.15	76%
VRWF20	Salem	8/7/2006	16:30	Storm	70	1.8451		65.5	65.5	1.9	50%
VRWF20	Salem	9/19/2006	13:00	Storm	8700	3.9395		5455.5	5455.5	15	25%
VRWF20	Salem	11/29/2006	12:00	Baseflow	10	1.0000		11.0	11.0	2.2	48%

18.0 APPENDIX B: County Livestock Data

Progam	Year	Domain	Domain Category	County	acres	Data Item	**Value**	# per acre
CENSUS	2007	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CATTLE, COWS - INVENTORY	**27,578**	0.053
CENSUS	2007	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CATTLE, COWS, BEEF - INVENTORY	**24,678**	0.047
CENSUS	2007	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CATTLE, COWS, MILK - INVENTORY	**2,900**	0.006
CENSUS	2007	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CATTLE, INCL CALVES - INVENTORY	**67,875**	0.130
CENSUS	2007	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CATTLE, ON FEED - INVENTORY	**12,068**	0.023
CENSUS	2008	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	cattle on grass	**52,907**	0.102
CENSUS	2009	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CHICKENS, BROILERS - INVENTORY		0.000
CENSUS	2010	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	CHICKENS, LAYERS - INVENTORY	**764**	0.001
CENSUS	2011	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	EQUINE, HORSES & PONIES - INVENTORY	**462**	0.001
CENSUS	2012	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	GOATS - INVENTORY	**196**	0.000
CENSUS	2013	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	HOGS - INVENTORY	**117257**	0.225
CENSUS	2014	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	SHEEP, INCL LAMBS - INVENTORY	**2965**	0.006
CENSUS	2015	TOTAL	NOT SPECIFIED	HUTCHINSON	520,911	TURKEYS - INVENTORY	**287665**	0.552
CENSUS	2016	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS - INVENTORY	**19,503**	0.049
CENSUS	2017	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS, BEEF - INVENTORY	**13,068**	0.033
CENSUS	2018	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, COWS, MILK - INVENTORY	**6,435**	0.016
CENSUS	2019	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, INCL CALVES - INVENTORY	**49,050**	0.124
CENSUS	2020	TOTAL	NOT SPECIFIED	TURNER	395,067	CATTLE, ON FEED - INVENTORY	**15,904**	0.040
CENSUS	2021	TOTAL	NOT SPECIFIED	TURNER	395,067	cattle on grass	**26,711**	0.068
CENSUS	2022	TOTAL	NOT SPECIFIED	TURNER	395,067	CHICKENS, BROILERS - INVENTORY	**35**	0.000
CENSUS	2023	TOTAL	NOT SPECIFIED	TURNER	395,067	CHICKENS, LAYERS - INVENTORY	**509**	0.001
CENSUS	2024	TOTAL	NOT SPECIFIED	TURNER	395,067	EQUINE, HORSES & PONIES - INVENTORY	**732**	0.002
CENSUS	2025	TOTAL	NOT SPECIFIED	TURNER	395,067	GOATS - INVENTORY	**133**	0.000
CENSUS	2026	TOTAL	NOT SPECIFIED	TURNER	395,067	HOGS - INVENTORY	**61412**	0.155
CENSUS	2027	TOTAL	NOT SPECIFIED	TURNER	395,067	SHEEP, INCL LAMBS - INVENTORY	**13145**	0.033
CENSUS	2028	TOTAL	NOT SPECIFIED	TURNER	395,067	TURKEYS - INVENTORY	**41**	0.000
CENSUS	2029	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CATTLE, COWS - INVENTORY	**27,889**	0.050
CENSUS	2030	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CATTLE, COWS, BEEF - INVENTORY	**27,271**	0.049
CENSUS	2031	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CATTLE, COWS, MILK - INVENTORY	**618**	0.001
CENSUS	2032	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CATTLE, INCL CALVES - INVENTORY	**84,267**	0.153
CENSUS	2033	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CATTLE, ON FEED - INVENTORY	**23,468**	0.042
CENSUS	2034	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	cattle on grass	**60,181**	0.109
CENSUS	2035	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	CHICKENS, BROILERS - INVENTORY	**225**	0.000
CENSUS	2036	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	EQUINE, HORSES & PONIES - INVENTORY	**621**	0.001

Progam	Year	Domain	Domain Category	County	acres	Data Item	**Value**	# per acre
CENSUS	2037	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	HOGS - INVENTORY	**8,932**	0.016
CENSUS	2038	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	SHEEP, INCL LAMBS - INVENTORY	**5,591**	0.010
CENSUS	2039	TOTAL	NOT SPECIFIED	KINGSBURY	552,500	TURKEYS - INVENTORY	**63,005**	0.114
CENSUS	2040	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CATTLE, COWS - INVENTORY	**18,620**	0.050
CENSUS	2041	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CATTLE, COWS, BEEF - INVENTORY	**15,791**	0.043
CENSUS	2042	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CATTLE, COWS, MILK - INVENTORY	**2,829**	0.008
CENSUS	2043	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CATTLE, INCL CALVES - INVENTORY	**44,776**	0.121
CENSUS	2044	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CATTLE, ON FEED - INVENTORY	**6,478**	0.018
CENSUS	2045	TOTAL	NOT SPECIFIED	MCCOOK	369,238	cattle on grass	**35,469**	0.096
CENSUS	2046	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CHICKENS, BROILERS - INVENTORY	**1,000**	0.003
CENSUS	2047	TOTAL	NOT SPECIFIED	MCCOOK	369,238	CHICKENS, LAYERS - INVENTORY	**1,647**	0.004
CENSUS	2048	TOTAL	NOT SPECIFIED	MCCOOK	369,238	EQUINE, HORSES & PONIES - INVENTORY	**680**	0.002
CENSUS	2049	TOTAL	NOT SPECIFIED	MCCOOK	369,238	HOGS - INVENTORY	**61,228**	0.166
CENSUS	2050	TOTAL	NOT SPECIFIED	MCCOOK	369,238	SHEEP, INCL LAMBS - INVENTORY	**4,115**	0.011
CENSUS	2051	TOTAL	NOT SPECIFIED	MINER	365,887	CATTLE, COWS - INVENTORY	**19,101**	0.052
CENSUS	2052	TOTAL	NOT SPECIFIED	MINER	365,887	CATTLE, COWS, BEEF - INVENTORY	**18,396**	0.050
CENSUS	2053	TOTAL	NOT SPECIFIED	MINER	365,887	CATTLE, COWS, MILK - INVENTORY	**705**	0.002
CENSUS	2054	TOTAL	NOT SPECIFIED	MINER	365,887	CATTLE, INCL CALVES - INVENTORY	**39,776**	0.109
CENSUS	2055	TOTAL	NOT SPECIFIED	MINER	365,887	CATTLE, ON FEED - INVENTORY	**4,734**	0.013
CENSUS	2056	TOTAL	NOT SPECIFIED	MINER	365,887	cattle on grass	**34,337**	0.094
CENSUS	2057	TOTAL	NOT SPECIFIED	MINER	365,887	CHICKENS, BROILERS - INVENTORY	**105**	0.000
CENSUS	2058	TOTAL	NOT SPECIFIED	MINER	365,887	CHICKENS, LAYERS - INVENTORY	**175**	0.000
CENSUS	2059	TOTAL	NOT SPECIFIED	MINER	365,887	EQUINE, HORSES & PONIES - INVENTORY	**384**	0.001
CENSUS	2060	TOTAL	NOT SPECIFIED	MINER	365,887	HOGS - INVENTORY	**13,335**	0.036
CENSUS	2061	TOTAL	NOT SPECIFIED	MINER	365,887	SHEEP, INCL LAMBS - INVENTORY	**3,953**	0.011
CENSUS	2062	TOTAL	NOT SPECIFIED	MINER	365,887	TURKEYS - INVENTORY	**36**	0.000

19.0 APPENDIX C: Public Notice Comments including EPA and Response to Comments

20.0 APPENDIX D: EPA TMDL Approval Letter